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New Vehicle Accident Study Final Report

A. L. Franklin
J. C. Lavender
D. A. Seaver
W. G. Stillwell

April 1991

Prepared for
the U.S. Army Safety Center
Ft. Rucker, Alabama
under a Related Services Agreement
with the U.S. Department of Energy
Contract DE-AC06-76RLO 1830

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NEW VEHICLE ACCIDENT STUDY
FINAL REPORT

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Richland, Washington 99352

SUMMARY

Safety goals set by the President, Secretary of Defense, and the Secretary of the Army required a three percent reduction in civilian and military injuries each year for the five-year period FY 1984-1988. The Army failed to meet this goal in each of the first four years and was not expected to meet the FY 1988 goal. One reason the Army did not meet this safety goal was the steady upward trend in new vehicle accidents. New vehicles include the M1 (tank), the M2/M3 (Bradley), High Mobility Multipurpose Wheeled Vehicle (HMMWV), Commercial Utility Cargo Vehicle (CUCV), Heavy Expanded Mobility Tactical Truck (HEMTT), and the Multiple Launch Rocket System (MLRS). During the seven-year period, CY 1981-1987, 2,109 new vehicle accidents occurred, causing 1,821 injuries, 26 fatalities, and costs of $30,812,601.

This report represents the result of an in-depth investigation of a one-year period to identify accident causes, their origin in the Army system, and needed corrective actions. The data used for this investigation was developed by Army safety professionals, and reported on DA Form 285 and DA Form 285-1. Results of the analysis of this information was subsequently verified through field visits to review actual operation and maintenance of these vehicles.

The principle problem areas identified for each vehicle include:

M1	Crushing in Turret Maintenance Traveling Over Rough Terrain Crushing in Doors/Hatches
Bradley	Mounting/Dismounting Traveling Over Rough Terrain
HEMTT	Following Too Closely/Speeding Road Crossing/Turning/Intersections
CUCV	Following Too Closely/Speeding Impaired Driving Backing Off Road Travel

Review of the Form 285 data did not identify any statistically significant problems areas for the HMMWV and MLRS vehicles.

Field reviews of operations and maintenance for these vehicles yielded a number of additional problems as identified by interviewed service members.

These included:

M1	Crushing under the main gun Loader seat/foothold instability Vehicle recovery operations Ice/Snow Handling
Bradley	Adequacy of training Loose objects in rear compartment Drivers hatch operation Internal crew communication
HMMWV	Impaired vision Seatbelt operation No parking gear Window drop
MLRS	Slips and falls Tilt forward cab Pod latch handle Insufficient/inappropriate personnel
HEMTT	Loss of brakes because of low air pressure Jacking vehicle Disorganized Dash 10 manuals
CUCV	Mounting/dismounting vehicle

Each of the problem areas identified from the analysis of the DA 285 and 285-1 forms and the field interviews were investigated for cause and potential mitigating measures. A number of recommendations were developed for each of the major problem areas.

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1.0 INTRODUCTION

Safety goals set by the President, Secretary of Defense, and Secretary of the Army required a three percent reduction in civilian and military injuries each year for the five-year period FY 1984-1988. The Army failed to meet this goal in each of the first four years and was not expected to meet the FY 1988 goal. One reason the Army did not meet this safety goal is the steady upward trend in new vehicle accidents. New vehicle accidents are defined, for the purposes of this study, as any accident in which one of the following vehicles is the primary vehicle: M1 (tank), M2/M3 (Bradley Fighting Vehicle), High Mobility Multipurpose Wheeled Vehicle (HMMWV, including M996, M997, M999, M1025, M1086), Commercial Utility Cargo Vehicle (CUCV, including M1007, M1008, M1008A, M1009, M1010, M1028), and Heavy Expanded Mobility Tactical Truck (HEMTT, including M977, M978, M983, M984, M985). "Primary vehicle" is here defined as the vehicle to which the materiel failure occurred, or that was misused, or which caused the accident to occur, or was the only military vehicle damaged in the accident. During the seven-year period, CY 1981-1987, 2,109 new vehicle accidents occurred, causing 1,821 injuries, 26 fatalities, and costs of $30,812,601.

Figure 1.1 graphically depicts both the magnitude (in dollars and number of accidents) and rate of increase in new vehicle accidents over the 1981-1987 time period. The steady increase in the number of new vehicle accidents is evident, but more striking is the rate of increase in total costs of accidents over this period, from about $5 million dollars in 1981 to almost $31 million dollars in 1987. As more and more of these vehicles are introduced into the inventory, barring changes in existing practices, these values can only be expected to increase.

The magnitude of these accidents and their associated losses poses a significant problem for mission readiness and realistic combat training, as well as the conservation of resources. Knowledge gained regarding the systemic generators of these accidents can significantly impact the planning and direction of future materiel acquisition programs. Additionally, the Army can directly enhance safety by concerted accident prevention in this area.

As a first step in addressing the problem of new vehicle accidents, these accidents were targeted for in-depth investigation and reporting for a one-year period to identify accident causes, their origin in the Army system, and needed corrective actions. This information was developed by Army safety professionals, and reported on DA Form 285-1 in addition to the usual DA Form 285 report. These data have now been analyzed and subsequent efforts to verify the results have been completed. Verification consisted of field visits to review the actual operations and maintenance of these vehicles. The results of these analyses along with specific recommendations targeted to each level of command for corrective actions are contained within this report.

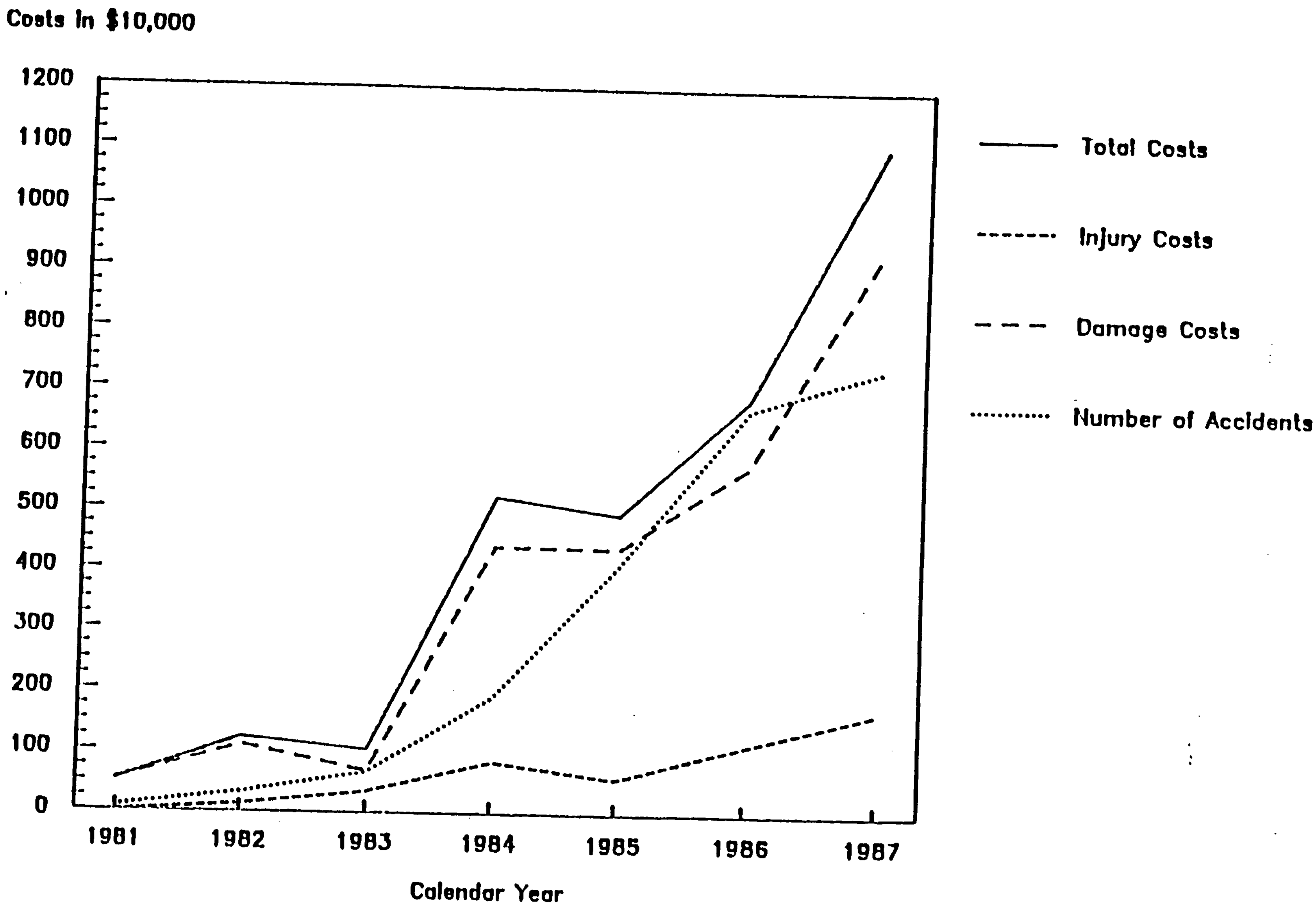


FIGURE 1.1. Number of Accidents and Costs for Six New Vehicles*

* CUCV, M1 Tank, M2/3 Bradley Fighting Vehicle, HEMTT, MLRS

2.0 METHODOLOGY

The analysis methodology for investigation of new vehicle accidents seeks to identify systemic problems that lead to accidents. It is based on the "3W" approach to accident investigation and prevention developed by the U.S. Army Safety Center (USASC):

- What happened? - categorized into human error, materiel failure, and environmental factors
- What caused it? - identification of the basic Army system inadequacy causing the accident
- What to do about it? - development of specific remedial measures targeted at specific command levels.

While new vehicles will have certain unique characteristics (for example, operators will have relatively less experience in the specific vehicle, at least initially) that will lead to accidents, they will also share characteristics and suffer safety problems similar to older vehicles. Therefore, analysis is not limited to the identification of unique aspects of new vehicles, but instead, addresses the entire range of problems suffered by the six vehicles that are the subject of this study.

Data used in this project came from two sources. The first source was raw data from the Army Form 285 which is collected into the Army Safety Management Information System (ASMIS) data base. The second source was direct interviews with individuals involved in the training and actual use of each vehicle. Discussion of the collection and analysis of the data from these two sources are contained in the next two subsections.

2.1 DA FORM 285-1 DATA COLLECTION AND ANALYSIS METHODOLOGY

The statistical data used in these analyses are in two parts. The first part comes from the Department of the Army Form 285. This form is used by an accident investigator, usually the commander or supervisor directly responsible for the operation, materiel, or people involved in the accident, to report detailed information about an accidents occurrence. These data are normally reported for all accidents classified A, B, or C, and certain class D accidents. They are sent to the USASC, coded, and entered into the Army Safety Management Information System (ASMIS) data base. This system was accessed to identify and examine information about accidents for the vehicles of interest in this study. The ASMIS contains 2109 accident reports for these vehicles, covering the seven-year period CY 1981-87.

The second type of the data used in this study was specifically collected to address the question of systemic causes of accidents for these six vehicles. For calender year 1985, these vehicles were targeted for an in-depth investigation and reporting effort using DA Form 285-1. Individual investigations were conducted by trained safety professionals and thus provided information more directly focused on systemic problems than the more general data contained in the DA Form 285. For the purposes of this data collection, an accident case was included if it met one or both of the following criteria: 1) the most seriously injured on-duty government person, military or civilian, lost 20 or more workdays or sustained a more serious injury, and 2) damage to Army property was $700 or more. Reports were received on 159 of these targeted accidents.

The focus of the analysis was the in-depth accident reports provided by the specific data collection effort and reported in DA Form 285-1. This narrative data focused on the primary vehicle (as determined by the original accident investigator) involved in the accident and usually provided insufficient information regarding secondary vehicles. Therefore, our analysis of DA Form 285-1 also focused on the primary vehicle.

Each narrative was individually examined by an analyst experienced in evaluation of narrative accident data. The analysts evaluated the circumstances of the accident in order to identify problem areas (i.e., characteristics of the accident that can be highlighted as hazardous or that require special awareness on the part of the vehicle operator/maintainer.) For example, examination of the 285-1 reports for the M1 tank revealed a hazard posed to personnel in close proximity to the turret while it was being rotated. "Crushing in turret" is thus the problem area identified.

Once problem areas were identified, the analysts examined the 285-1 reports to identify system inadequacies, that is, the deficient element(s) in the Army system that led to the accident. For example, the problem area "crushing in turret", discussed above, was found to be the result of "inadequate self-discipline in several of the accidents evaluated. Thus, the self-discipline of the individual involved in the accident was the point at which the Army system was inadequate to prevent the accident in question. Different accidents, identified as belonging to the same problem area, often resulted from different system inadequacies. The analysis summarized the system inadequacies within each problem.

Initial review of these narratives revealed a number of problem areas, specific to each vehicle type. Once problem areas were identified, tabulations were made of the system inadequacies found by the safety professionals to be contributory to the accidents. These system inadequacies were then aggregated within each problem area in order to gain understanding of accident causes and relative impacts of system inadequacies to each problem area.

Based upon the problem area findings discussed above, projections were made, separately for each vehicle, of the impacts of each of these problem areas for the 1981-87 time period. Numbers of accidents, injuries, and

fatalities were projected for each problem area by first determining the relative numbers of accidents in the sample of DA Form 285-1 data collected for the project, in the ASMIS data base for 1985, and the ASMIS data base for 1981-87. For example, there were 37 M1 tank accidents with DA Form 285-1 reports, 88 shown in the ASMIS for 1985, and 517 shown for 1981-1987. The accidents in the DA Form 285-1 thus represent 42 percent of the M1 tank accidents for 1985 and 7.2 percent for the 1981-1987 period.

This percentage was then used to calculate expected numbers of accidents, injuries, and fatalities for 1985 and 1981-1987. Continuing the above example using the problem area "crushing in turret," the 9 accidents represented in the DA Form 285-1 were assumed to represent 42 percent of the accidents associated with this problem area for all of 1985 (projecting 21 accidents), and 7.2 percent of the accidents for 1981-1987 (projecting 125 accidents).

In order to project injury, damage and total costs the reciprocal of the above percentages (representing the ratio of the number accidents in the two data pools) were multiplied times the dollar figures for the DA Form 285-1 accidents. For example, the injury cost of $36,220 for the problem area "crushing in turret" for the M1 tank when multiplied by the reciprocal of 42 percent (i.e., 2.381) results in an estimate of injury costs for all 1985 accidents of $86,238.

Average costs per accident were also calculated for the DA Form 285-1 data, and each of the estimated cost figures. These average figures will differ slightly due to differences in rounded calculations.

Materiel failures were investigated in a manner similar to that of other problem areas. Information from the DA Form 285-1 was first examined to understand key problem areas identified by the safety professionals. Four accidents with five materiel failures were identified in this way. Descriptions of the individual accidents and no projections are provided. Therefore, only brief descriptions of the materiel failures are provided. No injury or damage costs analyses were made because of the small data set.

Broader understanding of materiel failures was gained by analyzing ASMIS DA Form 285 coded data for the seven year period from 1981 to 1987. This type of analysis allowed examination of a broader range of relationships as well as evaluation of the extent of materiel failures in new vehicles. Detailed information was aggregated by system, subsystem and failure mode for each accident in order to examine the part of the system involved and extent of damage associated with classes of material failures.

The impact of environmental conditions on vehicle accidents was, for the purposes of this analysis, treated as a separate topic. While environmental conditions are seldom the unique cause of an accident, the failure of the vehicle operation and maintenance system to adjust to their presence often is. The significance of environmental conditions as causal agents in vehicle accidents cannot therefore be examined simply by examining

those cases where it can be shown that they were uniquely causal. Instead, their presence in accident situations must be examined in a more inferential manner in order to understand their importance as contributors to accidents.

One result of this approach is that the study of environmental conditions was not orthogonal to that of other problem areas. While clearly defined systemic problems and their solutions can be determined for other problem areas, environmental conditions are seldom directly causal. Their presence simply makes possible or exacerbates the impact other systemic problems.

The magnitude of the impact of environmental conditions on accidents was examined for two sets of accidents with the same methodology used for each set. The first set was based on the accident cases in the data sample for which DA Form 285-1 data were provided. For these cases, ASMIS data were used to identify the presence of contributory environmental conditions at the time of the accident. In Section C, block 34 on that form and/or in the narrative discussion of the accident (Section D, block 35) are shown the environmental conditions that in the judgment of the investigator "... caused or contributed to the accident" (as discussed in the DA Form 285 Unit Training Package) and thus represent the non-orthogonal contributory factor discussed above. The accident cases identified by the presence of these coded environmental conditions were pooled and calculations made of the total numbers of accidents, injuries, fatalities, and injury, damage, and total costs associated with each vehicle.

The second set of accidents included in the environmental analysis used the same DA Form 285 data resident on the ASMIS. Included were data for all accidents occurring in the 1985 calender year in which one of the six vehicles examined in this study was listed as the "primary" vehicle involved in the accident. Thus, this analysis was also based upon the "environmental condition" coded and entered into that system for each accident. Once again, calculations were made of the numbers of accidents, injuries, fatalities, and injury, damage, and total costs resulting from these accidents, subdivided by vehicle.

Projections were also made for environmental conditions, from the ASMIS data reflecting the presence of environmental conditions in the 1985 accidents to accidents for the 1981-87 time period. The method for making these projections was the same as for other problem areas. Proportions of vehicles involved in 1985 accidents which showed the presence of environmental conditions were calculated and applied to the vehicle accidents for the 1981-87 time frame to arrive at numbers of accidents, injuries, and fatalities. An average cost per accident and injury was calculated for 1985 and multiplied times the projected numbers of environmental accidents for 1981-87 to arrive at costs for the longer time period.

2.2 FIELD DATA COLLECTION AND ANALYSIS METHODOLOGY

Following completion of the analysis of the Form 285 data, site visits were undertaken to verify analysis conclusions through direct interviews with vehicle operators and crew. Three sites were selected to provide full coverage of all "new" vehicles to the depth that was anticipated to be required. Because of the success of the first two site visits the third visit was not required and was dropped. The interviews were conducted with two objectives in mind. This first was to verify conclusions drawn from analyzing the 285 and 285-1 data. The second objective was to identify any additional problem areas that may exist for these vehicles, that was not readily apparent from the 285 and 285-1 data analysis. Embedded within this second objective is a third potential objective of developing some insight into the relative significance of various problems areas as perceived by the vehicle crews.

The interviews consisted of a series of discussions in groups of 4 to 12 individuals. The makeup of the groups varied from training instructors and experienced vehicle commanders to recently assigned individuals with minimal direct experience. This makeup proved to be very satisfactory because it provided a broad spectrum of perspectives on training and operating experiences. The selection of particular individuals for the interviews was made by Army personnel at each of the visited sites. Makeup of the groups was influenced by suggesting particular job categories and skill levels of interest. As the interviews were conducted, the makeup of the discussions groups were adjusted as needed to obtain more information regarding particular issues.

The primary topics of interest were limited to the top two to four problems areas identified from the Form 285 and 285-1 data for each vehicle. This limitation was imposed to assure adequate time would be available for exploring potential problem areas that had not been identified through the analysis of the Form 285 and 285-1 data. The search for problem areas not identified in the 285 and 285-1 data consisted of unstructured (but guided) discussions beginning with general vehicle operations and leading to operator perceived hazards. Questions developed prior to the site visits were found to be awkward and excessively constraining to the individuals being interviewed.

The interviews were, for the most part, held in and around the vehicles themselves. This arrangement provided several interesting benefits. First, the individuals involved in the interviews appeared to be much more at ease around the vehicles. A portion of the discussions were held in an informal office environment. Under these circumstances, the individuals ability to relax and enter into meaningful dialogue seemed to be dependent upon that persons military rank. Lower ranked individuals contributed significantly more to the conversations when they were held around the vehicle. As the interviews moved into the office environment, these individuals became much more reserved and contributed less to the data collection process. Holding the discussions around the vehicles also provided the opportunity for the individuals to be reminded of particular activities and operations that

concerned them. Talking through the operations of the vehicles, along with actually performing some of the activities, provided an excellent perspective into the relative and perceived hazards for each vehicle.

Holding the interviews in and around the vehicles did, however, present some problems. There was a tendency for the individuals to take the discussions into areas that were really operational problems rather than safety issues. In addition, in some cases the discussions took place in confined areas where not all of the individuals could participate equally in the discussions. These problems were minimized by refocusing the discussion on safety problem areas and by repeating issues presented by one individual so that all individuals had the opportunity to consider each potential problem area.

For all vehicles except the CUCV and the HMMWV, multiple sessions were held with different interview groups being involved in each of the sessions. The initial session tended to be more general in nature (as would be expected) and the preliminary indications of this initial session were used to influence the makeup of the later discussion groups. As potential problem areas were identified for particular tasks, individuals with more direct involvement with those tasks were solicited for later discussions. This approach was used most extensively on the M1, Bradley, and MLRS vehicles. The nature and general consensus of the discussions for the other vehicles suggested less dependency on varying the group makeup. Because of the nature of the vehicle and the potential problem areas, similar to conventional civilian vehicles, the discussion for the HMMWV and the CUCV were completed with a single session.

The confirmation of problem areas identified in the 285 and 285-1 data was accomplished by obtaining a group consensus of these topics. Informal polling was used to determine how strongly each group felt about the relative significance of each problem area. In a number of cases, specific problem areas were supported by examples of personal experience in those problem areas.

Insight into causes (system inadequacies) for each identified problem area was obtained by discussing possible contributing factors and potential fixes for each problem area. For example, if the consensus of the groups were that experience was the best way to approach a problem area, several possible system inadequacies would be suggested. These could be insufficient training, insufficient procedures, inadequate supervision, or inadequate experience. The individuals interviewed had a tendency to suggest hardware fixes which would reduce the impact of these inadequacies, but would not directly address the inadequacies.

3.0 RESULTS

During the seven-year period, 2,109 accidents occurred in which one of the six types of new vehicles was the primary vehicle involved. The data for these accidents are summarized in Table 3.1 with total cost by year shown graphically. These accidents resulted in 1,821 injuries, 26 fatalities, and a total cost of over $30 million.

The upward trend in number of accidents is consistent across vehicle type as depicted in Figure 3.1. The CUCV and M1 tank show the largest numbers of accidents, although HMMWV accidents are increasing rapidly. Costs, as shown in Figure 3.2, generally follow trends in numbers of accidents, with two noteworthy exceptions.

First, although accidents continue to increase for the M1 tank, total costs associated with these accidents are decreasing. A second, rather striking result is the substantial increase in costs associated with the HEMTT in 1987. This finding is largely the result of a single accident resulting in approximately 75 percent of the 1987 total.

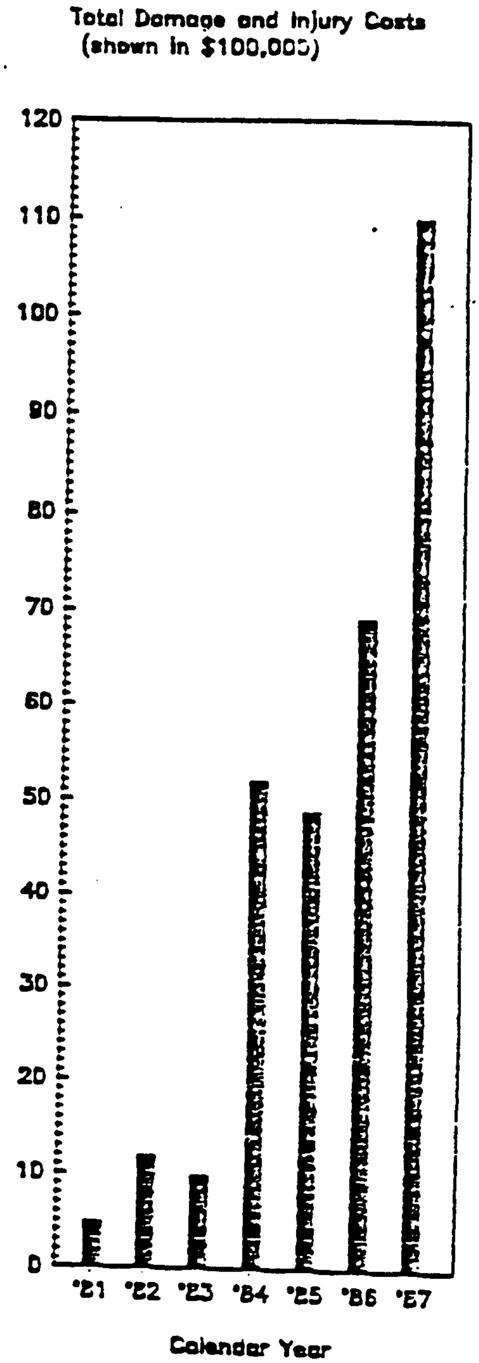
Accidents involving the CUCV accounted for 52 percent of the accidents, or 1100, of the 2109 accidents. Similarly, the CUCV also accounted for 51 percent of the total number of injuries, including fatalities, or 935 of the 1847 total injuries. The M1 tank accounted for 25 percent of the accidents and injuries or respectively 517 and 461. Eight percent, or 184, of the accidents occurred in the Bradley Fighting Vehicle (BFV). Of the 184 BFV accidents, 133 or 72 percent involved the M2. Approximately eight percent, or 169, of the injuries also occurred in the BFV. The HMMWV and the HEMTT were each involved in approximately seven percent of the accidents. The HEMTT was involved in 153 accidents, resulting in 137 injuries and the HMMWV was involved in 141 accidents producing 131 injuries. The MLRS was involved in 14 accidents or less than one percent of the total new vehicle accidents for the seven-year period.

During the seven-year period there were 26 fatalities, 62 percent, or 16, involved the CUCV. Of the remaining 10 fatalities four involved the HMMWV, two occurred in each of the BFV and M1 tanks, and one occurred in each of the MLRS and the HEMTT. Both of the BFV fatalities occurred in the M2.

The 2109 accidents resulted in $30,812,601 total injury and damage costs. 85 percent of the costs, or $26,138,536 were damage costs the remaining 15 percent or $4,674,065 were injury costs. Accidents involving the M1 accounted for approximately 50 percent of the damage costs or $12,966,929. The HEMTT had the second highest damage costs or $5,239,531, although, as previously mentioned, this number is somewhat misleading. CUCV accidents resulted in

TABLE 3.1. Summary by Vehicle Configuration CY 1981 - 1987

	MLRS	M1	BFV	HEMTT	HMMWV	CUCV	Annual Totals
1981							
Accidents	0	8	0	0	0	0	8
Injuries	0	8	0	0	0	0	8
Fatalities	0	0	0	0	0	0	0
Injury Cost	0	4865	0	0	0	0	4865
Damage Cost	0	509584	0	0	0	0	509584
Total Cost	0	514449	0	0	0	0	514449
1982							
Accidents	0	29	3	0	0	0	32
Injuries	0	29	3	0	0	0	32
Fatalities	0	0	0	0	0	0	0
Injury Cost	0	120460	12685	0	0	0	133145
Damage Cost	0	1091264	1793	0	0	0	1093057
Total Cost	0	1211724	14478	0	0	0	1226202
1983							
Accidents	1	46	12	1	4	0	66
Injuries	1	48	8	1	4	0	62
Fatalities	0	0	0	0	0	0	0
Injury Cost	1000	296745	23510	0	22415	0	343670
Damage Cost	12900	477025	146531	12451	27878	0	676785
Total Cost	13900	773770	170041	12451	50293	0	1020455
1984							
Accidents	1	66	34	9	4	56	190
Injuries	0	79	33	9	4	51	176
Fatalities	1	2	0	0	0	1	4
Injury Cost	47000	372420	93875	33555	4445	318360	827355
Damage Cost	0	3962743	155077	2500	15679	261691	4397690
Total Cost	47000	4335163	248952	36055	20124	580051	5225045
1985							
Accidents	5	65	34	15	9	254	409
Injuries	5	73	32	15	8	220	353
Fatalities	0	0	0	1	0	5	6
Injury Cost	5620	242240	94115	57160	22900	139880	561915
Damage Cost	3875	2566287	655934	227354	35431	880609	4369490
Total Cost	9495	2808527	750049	284514	58331	1020489	4931405
1986							
Accidents	5	116	46	57	25	416	669
Injuries	5	97	43	48	22	325	540
Fatalities	0	0	1	0	0	7	8
Injury Cost	3570	314995	239315	19610	17590	529275	1124355
Damage Cost	4100	2461581	1525253	209790	75833	1466124	5746681
Total Cost	7670	2776576	1768568	229400	93423	1995399	6871036
1987							
Accidents	2	140	53	67	99	374	735
Injuries	2	125	48	63	89	323	650
Fatalities	0	0	1	0	4	3	8
Injury Cost	515	622295	324360	35660	126010	569520	1678760
Damage Cost	85000	1898445	248319	4787436	549087	1776962	9345249
Total Cost	85515	2520740	572679	4823096	675097	2346482	11024009
Totals by Vehicle							
Accidents	14	517	164	153	141	1100	2105
Injuries	13	459	167	136	127	919	1821
Fatalities	1	2	2	1	4	16	26
Injury Cost	57705	1974020	787860	145985	193360	1557435	4674065
Damage Cost	105675	12966529	2736907	5239531	703906	4385386	26138536
Total Cost	121280	14940949	3524767	5385516	897268	5942821	30812601



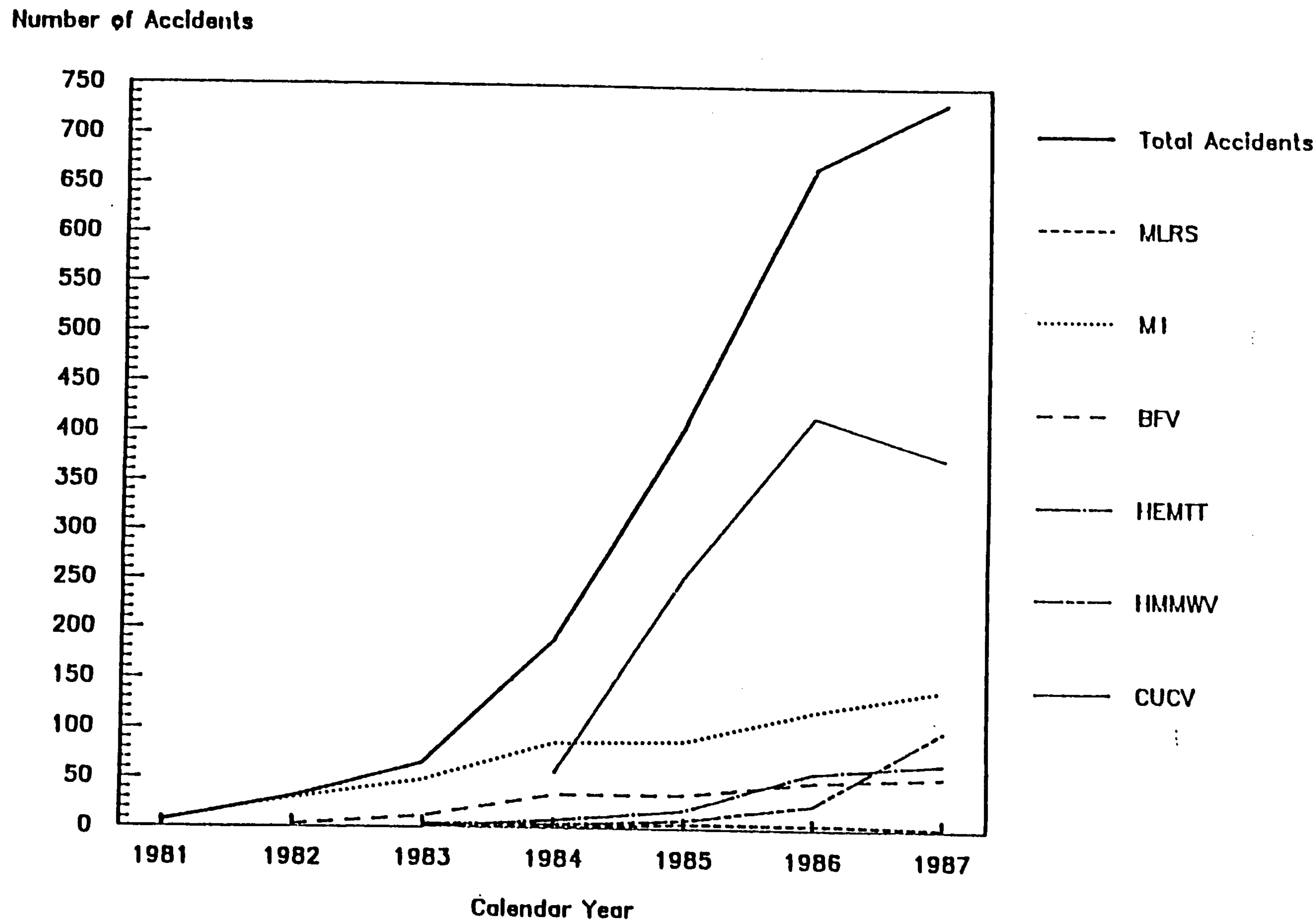


FIGURE 3.1. Numbers of Accidents by New Vehicle Type

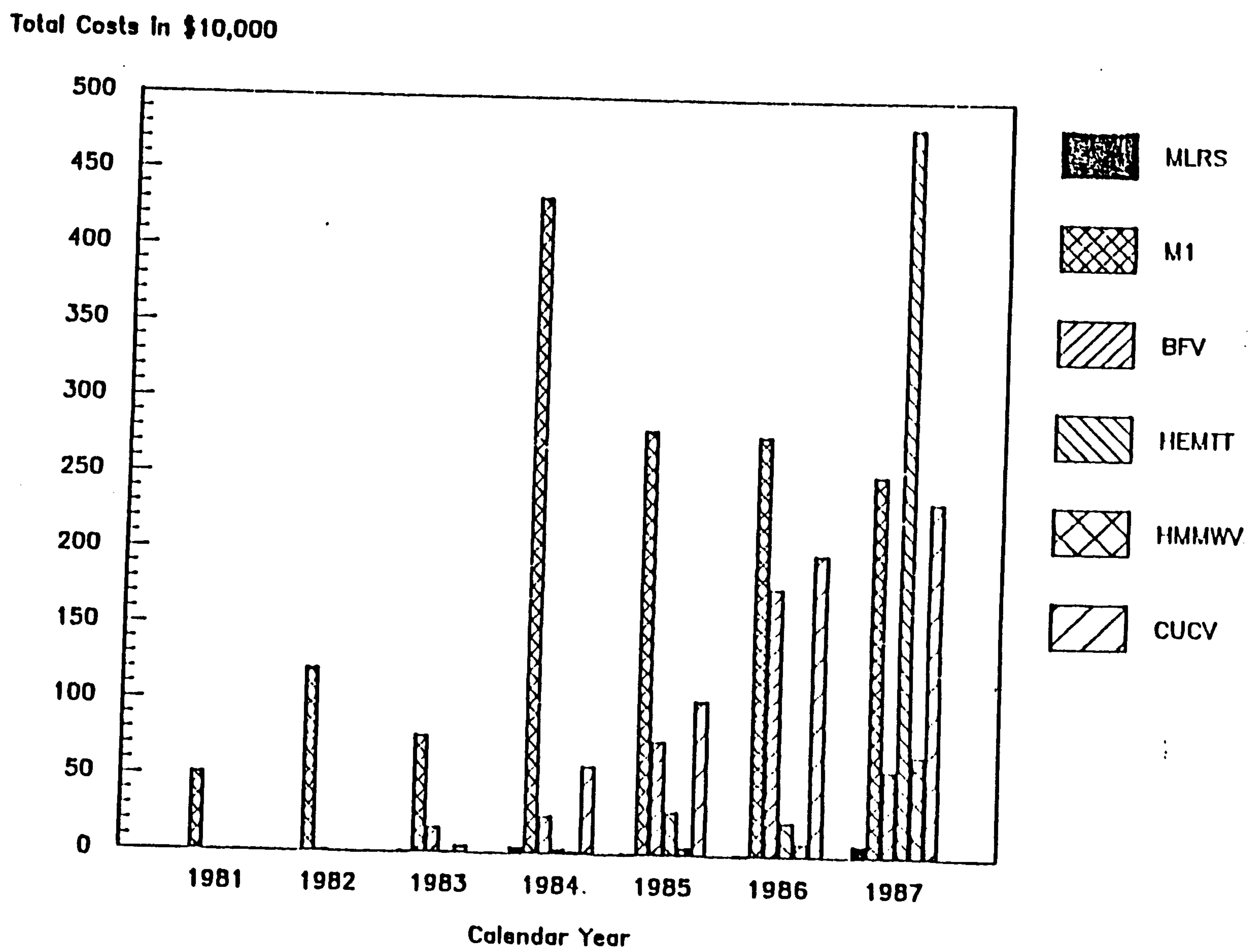


FIGURE 3.2. Total Damage and Injury Costs by New Vehicle Type

$4,385,386 damage with more than 50 percent of these costs due to the M1009 CUCV utility truck. The 184 BFV accidents resulted in $2,736,907 of damage with $1,360,492 and $1,376,415 associated with the M2 and M3 respectively. The HMMWV and the MLRS together accounted for approximately $810,000 of the total $26,108,554.

The majority of the injury costs were associated with the M1 and the CUCV. These two vehicles accounted for $3,531,456 or 75 percent of the injury costs. The 461 injury producing accidents in the M1 resulted in $1,974,020 of injury costs. The total CUCV injury costs, or $1,557,435, are largely responsible to accidents involving the M1008 and the M1009. The BFV ranks third with $787,860, the HMMWV is fourth ($193,360), the HEMTT ranks fifth ($145,985), and the MLRS was last, resulting in $57,705 of injury costs.

The following sections describe problem areas associated with each of the new vehicles for which DA Forms 285-1 were submitted during the recent target year. Each problem area begins with a summary of the accident statistics from the DA Form 285-1 sample, and estimates for the total accident statistics for the target year and the seven-year period (for the identified vehicle and problem area).

3.1 M1 TANK

3.1.1 Results From 285-1 Analysis

3.1.1.1 Problem Area: Crushing in Turret

	DA Form 285-1 Data (n=37)	Estimated for 1985 (n=88)	Estimated for 1981-87 (n=517)
Accidents	9	21	125
Injuries	9	21	125
Fatalities	0	0	0
Injury Cost	$36,220	$86,238	$503,055
Damage Cost	0	0	0
Total Cost	$36,220	$86,238	$503,055
Average Cost	$4,024	$4,106	$4,024

Description: Personnel do not correctly place feet in guarded foot rest, have feet slip from guarded position into unguarded position in turret during travel over rough terrain, or otherwise improperly position themselves in turret. Personnel responsible for traversing the turret do not properly check if turret is clear before traversing.

Hazard: Turret traverses unexpectedly or personnel are unaware of their position when turret traverses resulting in crushing and fracturing, often of feet and/or ankles.

Causes:

1. Inadequate Self-Discipline (Inattention, Inadequate Motivation) (56%)

   Example - Service member, while the M1 was performing a spin drill and traveling over rough terrain, foot slipped resulting in it being crushed between the turret and the hull of the M1. Service member was not attending to the position of his feet and the possibility of slipping.

2. Inadequate Experience (22%)

   Example - Service member, improperly positioned himself so that as turret turned to maintain a downrange orientation, his leg and foot were crushed between the turret and the hull. The service member was assigned as a mechanic and had no experience as a tanker.

3. Habit Interference (11%)

   Example - Service member moved to clear himself when the tank commander announced "power," but the toe of his boot was caught by the turret resulting in crushing the foot. Service member was used to having his boot extend over the loader's toe guard because of his large foot size.

4. Inadequate Written Procedures for Operation Under Normal Conditions (11%)

   Example - Service member was sitting in loader's seat during a live fire exercise resting his foot on the stowed loaders platform to avoid burning his leg on the hot spent cartridges on the floor. The turret turned catching his heel between the turret skirt and fixed equipment inside the turret. TM 9-2350-255-10-2 does not provide adequate procedures for the loader to place feet and legs to avoid hot spent cartridges without placing them in a position to be caught in the turret.

3.1.1.2 Problem Area: Maintenance

	DA Form 285-1 Data (n=37)	Estimated for 1985 (n=88)	Estimated for 1981-87 (n=517)
Accidents	6	14	84
Injuries	8	19	112
Fatalities	0	0	0
Injury Cost	$47,500	$106,875	$629,375
Damage Cost	0	0	0
Total Cost	$47,500	$106875	$629,375
Average Cost	$7,916	8,078	$7,948

Description: Personnel performing maintenance act in an unsafe manner when maintaining tracks, washing vehicles, using tools, lifting, and otherwise conducting maintenance activities on a stationary vehicle.

Hazards:

1. Not wearing safety goggles resulted in eye injuries from flying particles.

2. Improper lifting techniques resulted in heavy objects being dropped and causing injury.

3. Slipping on wet/icy surfaces caused falls and injuries.

4. Positioning of body during track maintenance led to injury when track unexpectedly moved or fell.

Causes:

1. Inadequate Self-Discipline (Inattention, Inadequate Motivation) (30%)

   Example - While service member was working on the track, it unexpectedly snapped off the sprocket dropping onto his hands. Service member did not pay attention to where his hands were placed so that he could not move them quickly.

2. Inadequate Unit Training (14%)

   Example - Service member was working underneath an M1 while another soldier was "breaking tracks" above him. A metal pin was sprung loose and struck the service member on the head. Unit training did not adequately address the safety precautions for working underneath the M1.

3. Inadequate Experience (14%)

   Example - Service member was verifying the hook-up sequence of batteries on the rear deck of the M1 underneath the gun. Another soldier announced "power," failed to observe the service member, and the gun rapidly lowered crushing the service member's lower back. The service member did not have enough experience to reinforce the school training received on this topic.

4. Fatigue (14%)

   Example - Service member in the previous example had been on continuous duty for 18-20 hours with only 4-6 hours of sleep.

5. Habit Interference (14%)

Example - Service member was installing a turret control box when the box slipped striking his knee and causing contusions. Service member was performing this task in a casual manner and as a result, did not take appropriate care.

6. Improper Use of Tool, Equipment, or Materiel (14%)

Example - Service member used the number 7 pin for a prying device to align the hinges of the mud guard. The pin slipped and struck him in the eye.

3.1.1.3 Problem Area: Traveling Over Rough Terrain

	DA Form 285-1 Data (n=37)	Estimated for 1985 (n=88)	Estimated for 1981-87 (n=517)
Accidents	5	12	70
Injuries	6	14	84
Fatalities	0	0	0
Injury Cost	$2,180	$5,190	$30,277
Damage Cost	0	0	0
Total Cost	$2,180	$5,190	$30,277
Average Cost	$436	$432	$438

Description: Personnel in M1 are jarred and bounced inside the tank as it travels over rough terrain.

Hazard: Bouncing and jarring causes personnel to strike hard surfaces in the M1 causing injuries.

Causes:

1. Inadequate Unit Training (20%)

Example - Service member was driving an M1 with darkness and tall grass obscuring his vision when the tank hit a hole causing it to bounce and the service member to sustain a fractured tailbone. Unit training did not adequately address the need to slow down when driving with obscured vision.

2. Inadequate Self-Discipline (Overconfidence) (20%)

Example - Service member was moving to his gunner's seat inside the moving M1 when he tripped, tried to steady himself, and inadvertently grabbed the track commander's panel switch. The override switch was activated raising the gun, and the breech came down striking the service member's thigh. The service member was overconfident in his ability to move within the moving M1.

3. Fatigue (20%)

Example - Service member had his hands placed inside the hatch in the path of the breech during cross country maneuvering. When the breech moved up, his hands were struck. Service member's attention was impaired because he had only "catnaps" during the previous 24 hours.

4. Environmental Conditions (20%)

Example - The tank commander, wearing night vision goggles, struck his head on the hatch rim when the M1 fell nose first into an eight-foot deep washout. Available light was insufficient for the night vision goggles to be effective.

5. Insufficient Information (20%)

3.1.1.4 Problem Area: Crushing in Doors/Hatches

	DA Form 285-1 Data (n=37)	Estimated for 1985 (n=88)	Estimated for 1981-87 (n=517)
Accidents	3	7	41
Injuries	5	12	69
Fatalities	0	0	0
Injury Cost	$45,730	$106,476	$621,111
Damage Cost	0	0	0
Total Cost	$45,730	$106,476	$621,111
Average Cost	$14,906	$15,210	$14,788

Description: Personnel place hands/fingers in doorways/hatches of the M1 where they may be crushed, fractured, or severed if the door/hatch moves unexpectedly.

Hazard: Heavy doors and hatches, in some instances driven hydraulically, can cause severe damage to body extremities placed in their path.

Causes:

1. Inadequate Unit Training (34%)

Example - While service member was mounting the loaders M240, a second service member opened the loader's hatch breaking the first service member's finger. Unit training did not adequately address the need for appropriate communication between crew members when accomplishing such tanks.

2. Inadequate Experience (33%)

Example - Service member was manually opening the Ready Ammunition Door using TM 9-2350-255-10-2. Service member failed to follow steps E through G (pp. 2-302, 2-303) resulting in his hands being placed inappropriately so that when he lost his balance, he was unable to remove his hand from the cutout in the door before the door slid behind the steel guard. Two finger tips were severed. The service member lacked experience in performing this task, thereby failing to follow the procedures that would have prevented this accident.

3. Inadequate Self-Discipline (Inattention) (33%)

Example - Service member was closing the ammunition semi-ready door when a second service member accidentally bumped the knee switch opening the ammunition ready door and catching the first service member's fingers between the two doors. The second service member, due to inattention, failed to note that the knee switch was in the lowered position, rather than in the stowed (up) position where it is supposed to be when not in use.

3.1.1.5 Problem Area: Mounting and Dismounting Vehicle

	DA Form 285-1 Data (n=37)	Estimated for 1985 (n=88)	Estimated for 1981-87 (n=517)
Accidents	2	5	28
Injuries	2	5	28
Fatalities	0	0	0
Injury Cost	$3,970	$9,452	$55,138
Damage Cost	0	0	0
Total Cost	$3,970	$9,452	$55,138
Average Cost	$1,985	$1,890	$2,042

Description: Personnel climbing on vehicles fail to maintain three-point contact, sometimes slipping and falling off or against the vehicle.

Hazard: Falling off or against vehicle leads to fractures, and/or contusions.

Causes:

1. Inadequate Unit Training (50%)

Example - Service member, while standing on top of the turret, slipped and fell hitting his head. Unit training inadequately emphasized need to maintain three-point contact procedures.

2. Inadequate Direct Supervision (50%)

Example - Service member failed to maintain three-point contact when climbing on an M1, lost his balance, and fell to the ground injuring his arm. Direct supervision failed to enforce the proper mounting/dismounting procedure.

3.1.1.6 Problem Area: Backing

	DA Form 285-1 Data (n=37)	Estimated for 1985 (n=88)	Estimated for 1981-87 (n=517)
Accidents	2	5	28
Injuries	4	10	56
Fatalities	0	0	0
Injury Cost	0	0	0
Damage Cost	$1,287,894	$3,066,414	$17,887,416
Total Cost	$1,287,894	$3,066,414	$17,887,416
Average Cost	$643,947	$613,282	$638,836

Description: Restricted vision and lack of proper ground guidance while backing caused M1s to strike another vehicle or object.

Hazard:

1. Use of smoke in tactical environment restricts vision causing backing M1 to run into another vehicle.

2. Haste prompted by tactical objectives leads to failure to observe vehicles/objects while backing.

Causes:

1. Inadequate Self-Discipline (Inadequate Motivation) (50%)

   Example - Track Commander ordered the M1 backed over the crest of a hill for concealment. He failed to see a jeep parked behind the hill in his haste to conceal the M1 and ran over the jeep.

2. Inadequate Written Procedures for Operations Under Normal Conditions (50%)

   Example - Service member moved his M1 rearward into a smoke screen generated by the M1 and collided with another M1 approaching from behind. Available procedures did not address need to maintain clearance between tanks when smoke is used.

3.1.1.7 Problem Area: Handling/Use of Hoffman Devices

	DA Form 285-1 Data (n=37)	Estimated for 1985 (n=88)	Estimated for 1981-87 (n=517)
Accidents	2	5	28
Injuries	2	5	28
Fatalities	0	0	0
Injury Cost	$1,190	$2,833	$16,527
Damage Cost	0	0	0
Total Cost	$1,190	$2,833	$16,527
Average Cost	$595	$566	$590

Description: Hoffman devices are used to simulate the M1 main gun firing. Improper handling/use of Hoffman devices results in a small explosion.

Hazards:

1. Flying objects caused by Hoffman explosion can strike personnel.

2. Hoffman explosion can cause burns and eye injury if set off close to personnel.

Causes:

1. Inadequate Unit Training (100%)

   Example - Service member was setting off unused Hoffman devices about 10 feet from the M1. The explosion caused an object to be thrown toward the M1 striking another service member. TM 9-1370-207-10 was not followed in setting off unused Hoffmans because of inadequate unit training in the use of pyrotechnic simulators.

3.1.1.8 Problem Area: Other

	DA Form 285-1 Data (n=37)	Estimated for 1985 (n=88)	Estimated for 1981-87 (n=517)
Accidents	8	19	112
Injuries	7	17	97
Fatalities	0	0	0
Injury Cost	$5,100	$12,142	$70,833
Damage Cost	$110,030	$261,976	$1,528,194
Total Cost	$115,130	$274,118	$1,599,027
Average Cost	$14,391	$14,427	$14,405

This problem area is an aggregate of singly occurring problems.

3.1.2 Results from Field Data Collection

3.1.2.1 Confirmation of 285-1 Identified Problem Areas

For the M1, four problem areas that were identified in the 285-1 data analysis were targeted for investigation in the field visits. They were:

- Crushing in turret,
- Maintenance,
- Traveling over rough terrain, and
- Crushing in doors/hatches.

Each of these problem areas were confirmed during the site interviews. It was the consensus of the groups interviewed that the relative significance (crushing in turret as most significant - crushing in doors/hatches as least significant) was probably accurate. However, the basis for the appraised significance was not strictly a perceived relative frequency.

Crushing in Turret

Crushing in turret seemed to be the most significant for two reasons in addition to the higher relative frequency indicated in the 285 and 285-1 data. Everyone interviewed had either some direct contact with someone that had experienced this accident or they themselves had personally been involved in a crushing accident. Furthermore, the perceived consequences of this accident caused the individuals to hold it in a higher regard. Interestingly though, those individuals that had personally experienced this accident seemed unable to fully communicate the magnitude of the consequences of this accident. One individual that had been involved in a crushing accident had only days before witnessed a crushing accident. This individual was functioning as the tank commander when he witnessed his loader foot being crushed the turret. Less than a week later, he himself was riding in the loaders position when his foot was crushed. He stated that his perception of the hazard increased at each stage through this sequence of events. He now states that protecting himself from a turret crushing is his highest priority when in the tank, however, he has not been able to transfer this sense of importance to his fellow crew members.

Members of the groups interviewed indicated the most likely cause of this accident was inadequate self-discipline, with the second most likely cause being habit interference. Habit interference, in this case, refers to placing feet in various, unsafe positions to improve service member stability and comfort. In general, the service members proposed solutions were all hardware fixes that would address both of the causes. The suggested remedies included such actions as additional shields, guards, and warning rings (a noticeable ridge beside the turret that would remind the loader of his feet position).

Maintenance

Group consensus indicated maintenance related accidents were of high significance because of the broad nature of the problem area. The wide variety of activities and the high frequency of occurrence of these activities seemed to dictate that this problem area would be significant. Within the maintenance problem area, track related activities were considered the most significant problem area. This significance appeared to be related to larger magnitude of forces involved (weight, tension, etc.). One individual stated he would not work on track related activities unless he absolutely had to. He had been involved in a track related accident that resulted in 192 stitches in his chest. Other maintenance related activities did not seem to pose as great a risk to the workers. The next significant activities were related to working on the gun tube. This risk was related to the unpredictability and suddenness in which accidents in this area could happen. The principle hazard around the gun tube was crushing and essentially everyone interviewed indicated their activities and movements around the vehicle were influenced by the potential of this hazard.

The interviews indicated the service members disagreed somewhat with the results of the Form 285 analysis, with respect to the causes for this problem area. General consensus was that fatigue and improper use of tools were the most likely causes for this problem area. The groups clearly felt that inadequate self-discipline, while it may contribute in some cases, was not the major cause of this problem. Each individual interviewed felt that their awareness and emphasis on safety suggested the other causes were more likely.

Traveling Over Rough Terrain

Traveling over rough terrain viewed as significant operational hazard, but not necessarily as a problem area. Additional padding and hand holds were suggested for the tank commander and loader positions. Consensus of the individuals interviewed indicated that events in this category were more routine occurrences than accidents. Although these events were expected to occur routinely, a number of individuals suggested potential mitigating changes that may reduced the severity of these events. Particular interest was focused on improving the environment of the loaders position. The suggestions included such things as increased thickness of the loaders hatches, increased padding inside the turret, additional handhold both inside and out, and additional hazard stickers to provide more warning of various hazards.

In general, the interview groups agreed with the Form 285 and 285-1 findings regarding causes. They felt that the key to preventing accidents in this area was experience (ie. training). The feeling was that experience was the primary factor in determining whether other potential causes (such as fatigue, environmental conditions, and self-discipline) would ever become a factor in an accident. It was generally felt that early training experiences (AIT rather than unit training) needed to be more realistic.

Crushing in Doors/Hatches

Crushing in doors/hatches was also considered a significant operational hazard rather than a problem area. Individuals justified this opinion by considering the potential magnitude of the likely resultant injuries. It was generally felt that while the consequences of crushing in doors/hatches would probably be somewhat more severe than those for traveling over rough terrain, it was simply a part of the routine hazards of their occupation.

Again the principle cause for this problem area was attributed to experience. Individuals felt that since this was really a routine hazard, gaining realistic experience was the key to dealing with the problem.

3.1.2.2 Additional Identified Problem Areas

The following items of interest that do not explicitly appear in the findings from the Form 285 and 285-1 analysis were raised during the interviews. A number of these items represent subsets of problem areas previously identified and are indicated here as such. However, several of the items represent problem areas that have not surfaced in the Form 285 data. For these items, more extensive discussion is provided.

Crushing under main gun: This problem was mentioned in conjunction with typical maintenance related accidents. The principle hazard is the sudden drop of the gun tube. The hazard is currently dealt with through unit training and experience.

Loader seat/foothold: This problem refers to the difficulty loaders have in finding and maintaining solid footing when traveling over rough terrain. Individuals felt the seat should be re-designed with this second function (foothold) more in mind.

Vehicle recovery: This activity was unanimously portrayed as the most hazardous activity associated with the M1. The explanation for why this has not surfaced as a problem area was that the individuals were so aware and respectful of the dangers associated with this activity, that they took extra cautions. Several accounts were related where near accidents had occurred. The contributing causes that were expected to result in some future accident of this type included fatigue, lack of experience, and use of improper procedure due to time performance requirements. The individuals interviewed indicated this hazard is increased greatly when performed under NBC conditions.

Operating hatches during movement: This item is a subset of crushing in doors/hatches. It typical occurs when pressures are felt to perform certain activities within time constraints. The individuals recognized the increased hazards and felt that this was typically a judgement call that was not always wisely made. They further recognized that current procedures did not support this practice.

Load uncouple/recoupled automatic-realignment: During a loading activity inside the M1 turret, the automatic target tracking system is disengaged to facilitate the reloading activity. However, during this time the tracking operation continues electronically, and the proper gun orientation continues to change. At the completion of the loading operation the tracking system is re-engaged, resulting in a sudden and sometime substantial re-adjustment of the gun position. This sudden change in gun position occurs exactly at a time when the loader is most involved (closest to) the gun itself. Consensus of the interview groups was that this represented a significant hazard to the loader and that experience and/or training were the principle mechanisms for currently dealing with the hazard. Some opinions were expressed that slight modifications to the location of the re-engagement switch may help this problem.

Body position is essential to current preventive mechanisms: The item crosses over a number of identified problem areas. In essence, the individuals felt the principle mechanism for preventing most accidents was maintaining the proper body position. This implies most emphasis should be placed on training and supervision of tasks for all known problem areas.

Fatigue: Fatigue was unanimously considered the biggest contributor to all known and unknown problem areas. However, consensus of the groups was that fatigue was a contributing factor, not a direct cause. Furthermore, there was a recognition that fatigue was an inevitable condition that would need to be compensated for through experience, training, and supervision.

Towing operations: Among the lesser concerns of the groups was towing operations. The principle hazardous activity was associated with attaching the tow bar from the towing vehicle. The majority of the individuals interviewed felt uncomfortable performing this operation and several of them had experienced near miss accident situations. Most felt that the procedures for towing operations did not fully address the hazards and that the operation occurs infrequent enough to maintain sufficient familiar expertise. Some hardware modifications were suggested (such as a redesigned tow bar) as possible mitigating measures.

Ice/snow handling: Only a few of the individuals interviewed had any experience in handling the M1 under snowy and icy conditions. These individuals felt that the only preparation they had received for this activity was field level experience. They further expressed the opinion that improved training and procedures for this particular activity were necessary. The training/procedure improvements should include not only how to maintain control of the vehicle, but also what to do when the vehicle goes out of control. They further felt that ice and snow handling required exceptional skill and should be procedurally limited to very experience drivers.

HET - heavy equipment transport: This refers to the process of loading the M1 tank on rail cars for long distance transport. This activity was considered hazardous because to the tight tolerances and precision in which these activities must be performed. Often, these activities occur late at night or

early morning when fatigue competes with this required precision. In addition, the activities can often be associated with increased pressures to meet time schedule requirements. This activity apparently does not occur frequently and only one or two individuals interviewed had any direct knowledge or experience in this area.

Dash 10 describes trouble shooting but not problem solving: A number of individuals, but not a consensus, expressed the opinion that the Dash 10 manuals describe the procedures needed to identify a problem, but they offered little help in how to solve the problems. While this issue was not widely expressed by individuals, there was some general indications across all vehicles that the Dash 10 manuals do not completely serve the needs of the service member. In some cases several different manuals (including some that were officially outdated and replaced) needed to be used to completely address problems. This was even more of a problem with the HEMMT.

TC ammo door: Inside the turret, there are two doors that provide access to the stored ammunition. One door, on the loaders side, is operated via a knee switch and has a safety interlock to prevent it from closing on the loaders arm. (This interlock does not work for the last 3 inches of the door closing.) The other door is behind the tank commander and provides access to an extra storage compartment for ammunition. This door is crank operated and has no interlocks. The hazard exists when the tank commanders door is open and ammunition is being retrieved from this extra compartment. Several individuals described situations that had occurred where the tank commander had become injured (severed fingers) when the loaders door mysteriously opened and passed into the tank commanders opened access area. There are no safety interlocks on the loaders door that apply to when the door opens. Spurious electrical signals were thought to have caused the loaders door to open. In these cases, all individuals interviewed felt proper precautions and procedures had been followed and that no amount of training or experience could have prevented the accidents.

Fire extinguishers: Several individuals indicated that the fire suppression systems in the M1 were prone to unintentional discharge. While this did not necessarily represent a direct hazard (except for possible cryogenic burns), it did represent a significant nuisance and potential contributor to other problem areas.

3.2 BRADLEY FIGHTING VEHICLE (M2/3)

3.2.1 Results From 285-1 Analysis

3.2.1.1 Problem Area: Mounting/Dismounting

	DA Form 285-1 Data (n=16)	Estimated for 1985 (n=34)	Estimated for 1981-87 (n=184)
Accidents	3	6	34
Injuries	3	16	34
Fatalities	0	0	0
Injury Cost	$8,520	$18,128	$97,931
Damage Cost	0	0	0
Total Cost	$8,5200	$18,128	$97,931
Average Cost	$2,840	$3,021	$2,880

Description: Personnel climbing on vehicles fail to maintain three-point contact, sometimes slipping and falling off or against the vehicle.

Hazard: Falling off or against vehicle leads to fractures, and/or contusions.

Cause:

1. Inadequate Self-Discipline (Inattention, Inadequate Motivation) (100%)

   Example - Service member, due to inattention, lost his balance while stepping down from a BFV and hit his shoulder on another BFV dislocating his shoulder.

3.2.1.2 Problem Area: Traveling on Rough Terrain

	DA Form 285-1 Data (n=16)	Estimated for 1985 (n=34)	Estimated for 1981-87 (n=184)
Accidents	3	6	34
Injuries	5	11	57
Fatalities	0	0	0
Injury Cost	$990	$2,106	$11,379
Damage Cost	$200	$425	$2,298
Total Cost	$1,190	$2,531	$13,677
Average Cost	$396	$421	$402

Description: Personnel in M2 are jarred and bounced inside the vehicle as it travel over rough terrain.

Hazard: Bouncing and jarring cause personnel to strike hard surfaces in the M2 causing injuries.

Causes:

1. Inadequate Self-Discipline (Inattention) (25%)

   Example - Service member did not pay enough attention to the road features ahead of the vehicle to recognize a deep washout and hold on tightly when the BFV hit the washout. As a result, the service member was bounced into the turret sustaining a blunt trauma on the abdomen.

2. Inadequate Unit Training (25%)

   Example - Service member operating an M2 BFV drove into a ditch obscured by tall grass rolling the vehicle and injuring himself and other soldiers. Unit training did not adequately address awareness of terrain hazards.

3. Fatigue (25%)

   Example - In above example, service member was fatigued by 12 hours of continuous duty which reduced his alertness.

4. Habit Interference (25%)

   Example - Service member was sitting on a bench in the M2 BFV when it went through a ditch, throwing him forward, striking his groin on a metal lever. Going through a second ditch, service member threw his head back against the rim of the hatch. Service member was not wearing a seat belt because of his expectation (habit) of the need to dismount quickly.

3.2.1.3 Problem Area: Parking Vehicle

	DA Form 285-1 Data (n=16)	Estimated for 1985 (n=34)	Estimated for 1981-87 (n=184
Accidents	2	4	23
Injuries	5	11	58
Fatalities	0	0	0
Injury Cost	$13,200	$28,085	$151,724
Damage Cost	$1,000	$2,127	$11,494
Total Cost	$14,200	$30,212	$163,218
Average Cost	$7,100	$7,553	$7,096

Description: When parking the BFV, brakes and transmission inappropriately used, particularly in conjunction with shutting off the vehicle.

Hazard:

1. If brake is not set and vehicle is not in neutral, accidental revving of the engine will cause the vehicle to move, possibly striking another vehicle, object, or person.

2. If brake is not applied when engine is in neutral while engine is being turned off, the vehicle can roll into another vehicle, object, or person.

Causes:

1. Inadequate Self-Discipline (Inadequate Attention) (100%)

   Example - Service member, after parking the BFV, showed inadequate attention when he took his foot off the brake while shutting off the engine. The vehicle rolled three feet into a POV.

3.2.1.4 Problem Area: Maintenance

	DA Form 285-1 Data (n=16)	Estimated for 1985 (n=34)	Estimated for 1981-87 (n=184)
Accidents	2	5	23
Injuries	1	2	12
Fatalities	0	0	0
Injury Cost	$850	$1,808	$9,770
Damage Cost	$19,500	$41,489	$224,137
Total Cost	$20,350	$43,297	$233,907
Average Cost	$10,175	$8,659	$10,169

Description: Personnel performing maintenance act in an unsafe manner when maintaining tracks, washing vehicles, using tools, lifting, and otherwise conducting maintenance activities on a stationary vehicle.

Hazards:

1. Fire caused by inappropriate electrical maintenance.

2. Back injury caused by improper lifting.

Causes:

1. Equipment/Materiel Improperly Designed/Not Provided (50%)

   Example - While removing machine gun from the turret, an Army civilian caught the machine gun receiver in a tight space and ruptured a disk in his lower back. The gun and turret are not designed for easy removal of the gun by a person standing in the turret.

2. Improper Use of Tool, Equipment, or Material (50%)

Example - Service member used cut cable clamps to service the electrical cable and did not remove the clamps. The clamps cut into the electrical wires, causing a short and a fire.

3.2.1.5 Problem Area: Turret Crushing

	DA Form 285-1 Data (n=16)	Estimated for 1985 (n=34)	Estimated for 1981-87 (n=184)
Accidents	1	2	12
Injuries	1	2	12
Fatalities	0	0	0
Injury Cost	$3,600	$7,659	$41,379
Damage Cost	0	0	0
Total Cost	$3,600	$7,659	$41,379
Average Cost	$3,600	$3,829	$3,448

Description: Personnel do not correctly place feet in guarded foot rest, have feet slip from guarded position into unguarded position in turret during travel over rough terrain, or otherwise improperly position themselves in turret. Personnel responsible for traversing the turret do not properly check if turret is clear before traversing.

Hazard: Turret traverses unexpectedly or personnel are unaware of their position when turret traverses resulting in crushing and fracturing, often of feet and/or ankles.

Causes:

1. Inadequate Self-Discipline (Overconfidence) (100%)

Example - Service member as gunner on an M2 did not realize that his CVC helmet was unplugged and could not inform the Track Commander that he was in the turret shield door when power was on. The service member was inattentive to his CVC helmet being plugged in and was overconfident in his ability to perform his function, thereby placing himself in the turret.

3.2.1.6 Problem Area: Crossing Roads

	DA Form 285-1 Data (n=16)	Estimated for 1985 (n=34)	Estimated for 1981-87 (n=184)
Accidents	1	2	12
Injuries	1	12	12
Fatalities	0	0	0
Injury Cost	0	0	0
Damage Cost	$16,098	$34,251	$185,034
Total Cost	$16,098	$34,251	$185,034
Average Cost	$16,098	$17,125	$15,419

Description: Vehicle operators, when stopping at, entering, or leaving road crossings fail to see, or appropriately judge speed and/or spacing necessary for safe crossing.

Hazard: Broadside collisions result from inappropriate entry into cross traffic.

Cause:

1. Inadequate Self-Discipline (Inattention) (100%)

   Example - Track Commander's CVC helmet cord had come unplugged without his recognition because of inattention. As a result, he was unable to communicate at a road crossing that there was crossing traffic. The driver assumed the road was clear, pulled onto the road, and struck the side of a truck.

3.2.1.7 Problem Area: Other

	DA Form 285-1 Data (n=16)	Estimated for 1985 (n=34)	Estimated for 1981-87 (n=184)
Accidents	4	9	46
Injuries	4	9	46
Fatalities	0	0	0
Injury Cost	$940	$2,000	$10,804
Damage Cost	$30,523	$64,942	$350,839
Total Cost	$31,463	$66,942	$361.643
Average Cost	$7,865	$7,348	$7,861

This problem area is an aggregate of singly occurring problems.

3.2.2 Results from Field Data Collection

3.2.2.1 Confirmation of 285-1 Identified Problem Areas

For the Bradley, two problem areas identified in the 285-1 data analysis were targeted for investigation in the field visits. They were:

- Traveling over rough terrain and
- Mounting/dismounting.

Both of these problem areas were confirmed during the site interviews. It was the consensus of the groups interviewed that traveling over rough terrain was substantially more significant than mounting/dismounting.

Traveling Over Rough Terrain

Although all individuals interviewed agreed that traveling over rough terrain represented a significant problem area for the Bradley (especially for the loader and observer positions), all individuals also unanimously disagreed with the causes identified in the Form 285 and 285-1 analysis. According to the individuals interviewed, the principle cause for this problem was a lack of communication between the driver and other crew members. The group felt that if better information were provided to other crew members, they would be better prepared for the violent movements. The group did acknowledge this communication was dependent upon the driver having good terrain information available to him (not always possible).

The group indicated this problem area was further aggravated for the loader and observer because of the physical environment in which they ride (limited or no visible references) and by their need to attend to housekeeping activities (re-stowing loosened articles) during terrain traverses.

Mounting/Dismounting

Each interview group agreed with the findings from the Form 285 analysis for this problem area. Furthermore, they agreed that the most likely cause of accidents in this area would be due inadequate self-discipline, especially inattention. General consensus was that the vehicle did require caution when mounting and dismounting, but that reasonable mechanisms had been included in the design to facilitate mounting/dismounting. Furthermore, the hazards of improper mounting/dismounting were sufficiently obvious and well enough discussed to suggest inadequate self-discipline, especially inattention would be the most likely causes of accidents in this area.

3.2.2.2 Additional Identified Problem Areas

The following items of interest that do not explicitly appear in the findings from the Form 285 analysis were raised during the interviews. A number of these items represent subsets of problem areas previously identified

and are indicated here as such. However, several of the items represent problem areas that have not surfaced in the Form 285 data. For these items, more extensive discussion is provided.

Meaningful and sufficient training: The general consensus of the groups interviewed felt Advance Individual Training (AIT) was proper for introducing service members to new vehicles but fell short of providing realistic training to become skilled operators. However, individuals completing this training were sufficiently trained to be considered qualified vehicle operators. A substantial amount of unit training would be required before any person could be considered an experienced operator. The amount of training that would be required to become a skilled operator was dependent upon difficulty and variation of the training situation presented to the operator. Most individuals felt that real training occurred on the job.

Drivers hatch: Two problems identified were associated with the drivers hatch. First was a concern over the shearing of a safety pin that is used to hold the drivers hatch open. Concern was expressed by a few of the individuals interviewed, that the pin was not substantial enough to be trusted to hold the hatch open during rough terrain travel. Interestingly, while everyone interviewed agreed the use of the pin was a required safety precaution, during a brief orientation inspection of the vehicle it was found that this pin had not been installed.

A second concern regarding the drivers hatch related to the location of the hatch release lever. When the hatch is latched in a half-open position, releasing the hatch to open or close it requires the service member to reach under the hatch and release the level. The body position required to accomplish this act is somewhat awkward and can contribute to a number of possible accidents, including crushing in the hatch and falling from the vehicle. To reduce the hazard associated with this activity, most individuals attach a strap to the lever when it is first locked into the half-open position. This strap is then used to release the lever without getting your arm under the hatch.

Loose objects in the rear compartment: One of the principle hazards to the loader and observer in the rear part of the vehicle is collision with loose objects. The interview groups indicated a significant amount of the loader/observer time is spent restoring loosened equipment during rough terrain travel. This housekeeping effort is necessary to prevent collisions with these loose objects, however, the housekeeping process contributes to the problem area of traveling over rough terrain by requiring the loader/observer to move from a secure seating arrangement. These two competing interests (remaining seated during rough terrain travel and maintaining a safe loader/observer space) cause the individuals to make judgement decisions regarding which action will result in better safety.

Weak internal communication capability: It was the unanimous consensus of the interview groups that the electronic communications equipment used to communicate between crew members contributed significantly to the occurrence

of various accidents. The communications equipment was described as unreliable and resulted in crew members attempting communication by other less effective means. this communication problems was felt to contribute to the problem areas of traveling over rough terrain and crushing in turret. For traveling over rough terrain, the driver is unable to pass adequate warnings to other crew members of impending rough terrain. This denies those crew members sufficient time to prepare themselves for the violent motions associated with this type of travel. For the crushing in turret problem, malfunctioning equipment causes loader/observers to communicate through the open turret door, frequently needing to physically reach into turret area to get the attention of the other crew members. This situation causes the turret door to be open at inappropriate times and places the loader/observer in a hazardous situation. The risk of this activity is recognized by the Bradley crew, however, this risk is tolerated in order to accomplish other important tasks.

3.3 HMMWV

3.3.1 Results From 285-1 Analysis

No consistent pattern of problem areas for the HMMWV was identified from the Form 285-1 Analysis.

3.3.2 Results From Field Data Collection

3.3.2.1 Confirmation of 285-1 Identified Problem Areas

For the HMMWV, no consistent problem areas were identified in the Form 285 data analysis. As a result, field data collection activities became the primary source form the identification of potential vehicle problem areas. Following collection of data from the site visits, later year Form 285 and 285-1 (which for consistency and projection reasons could not be included in the original Form 285 analysis) data has been examined to confirm statements and impressions given during the site visits.

3.3.2.2 Additional Identified Problem Areas

The following items of interest were raised during the interview session for the HMMWV. Because of the basic similarity of this vehicle to standard civilian vehicles, the identified items of interest tended to result from a general comparison of the HMMWV to common civilian vehicles.

Impaired vision: Several features of the HMMWV create a situation where accidents may occur because of impaired vision. The current physical structure of the windshield frame creates two significant blind spots for the driver (one on each side of the vehicle) that can contribute to road crossing and intersection hazards. Currently drivers compensate for these blind spots by making a conscious effort to physically look around the blind spots. The

magnitude of these blind spots requires this special effort and places additional responsibility on the vehicle drivers to be sufficiently self-disciplined to make this effort.

An additional and similar problem occurs as the result of the placement of the vehicles mirrors. Mirrors are traditionally used to compensate for vision blind spots. On the HMMWV, the passenger side mirror is located essentially within the blind spot itself. In order to position the mirror so that even a portion of this mirror is visible to the driver, the mirror must be adjusted to a position where the utility of the mirror is greatly reduced. This feature may make the HMMWV unusually susceptible to backing and normal traffic related hazards.

Seat belt operation: A number of lesser concerns were expressed by the interview group. Among these was a concern over how the seat belts in the HMMWV operated. There are two common modes for seat belts to operate. One is like the standard airline seat belt where the passenger fastens the belt and then pulls the strap tight. The second type is typical of commercial automobiles. For this type the passenger fastens the belt and an automatic retraction mechanism pull the slack out of the belt, but it remains loose and does not fasten securely. An integral part of this second type is some inertial lockup system that secures the belt when excessive forces are encountered. The seat belts in the HMMWV are an interesting combination of these two operations. When the operator fastens the belt and automatic retraction mechanism pulls the slack of the belt. However, no inertial lockup system exists to secure the belt when excessive forces are encountered. Instead, it is the obligation of the driver to also pull excess from the belt to make it completely secure. It was the feeling of the interview group that this type of operation could confuse some vehicle operators into believing their restraint systems were properly secured by just fastening the belt, but not tightening it.

No parking gear: Another lesser concern was the fact that the vehicle did not have a parking gear, even though it had an automatic transmission. Again, this represents a minor difference from civilian vehicles that the group thought may contribute to inattention types of accidents.

Window drop: The mechanisms used to operate the windows in the HMMWV essential use gravity to lower the window (as opposed to a gear driven system). the windows are held in the up position by pin that is accessible from inside the vehicle. Furthermore, a metal lip is attached to the top of the windows and protrudes into the vehicle approximately 1.5 inches. It is common for the pins securing these windows to become dislodged allowing the window to suddenly drop open. A number of the vehicles examined during the site visit had cracked windows from these types of drops. The group expressed concern that the metal lip could strike a passenger when the window drops. This problem could be significant if the passenger had recently be involved in long hours of being on duty and was leaning against the window in an attempt to catch up on his sleep.

3.4 MLRS

3.4.1 Results From 285-1 Analysis

No consistent pattern of problem areas for the MLRS was identified from the Form 285-1 Analysis.

3.4.2 Results From Field Data Collection

3.4.2.1 Confirmation of 285-1 Identified Problem Areas

For the MLRS, no consistent problem areas were identified in the Form 285 data analysis. As a result, field data collection activities became the primary source form the identification of potential vehicle problem areas. Following collection of data from the site visits, later year Form 285-1 (which for consistency and projection reasons could not be included in the original Form 285 analysis) data was examined to confirm statements and impressions given during the site visits.

3.4.2.2 Additional Identified Problem Areas

The following items of interest were raised during the interview session for the MLRS.

Tarp covering contributing to falls: Several members of the interview group indicated the canvass tarp used to cover the vehicle was need only for a small box in one corner of the vehicle. They further indicated that a number of hazards were associated with installing and removing the tarp. Principle among these were slips and falls. Often, the vehicle has some moisture collected on it and removing/installing the tarp under these conditions requires extra care. (Note: While removing the tarp to facilitate the brief vehicle orientation on this site visit, the service member in fact slipped and fell on the vehicle. Primarily due to experience, the service member was not injured.) It was the consensus of the interview group that this tarp should be replaced by a smaller more localized cover which protected the electronics box alone.

Tilt forward cab: When maintenance is required on the MLRS engine, the cab of the vehicle is tilted forward using a crank and a worm gear type drive. The position required of the service member to operate this crank places directly in the path of the cab should it's restraint systems fail. A number of individuals interviewed stated they would not perform this operation if at all possible because of their lack of trust in the restrain system. It was the general consensus of the group that a better restraint system or safer tilting procedures should be developed.

Pod latch handle sudden release: The rocket pod system uses a mechanical latch at the front of the pod to secure it in place. Under particular circumstances the handle of this latch can essentially become spring loaded. A safety chain has be included in the design of the latch mechanism to prevent

the handle from suddenly swinging outward and striking the operator during pod unloading operations. A number of individuals interviewed had either experienced or personally witnessed this hazard. It was felt that this hazard should be better addressed in the procedures describing the pod unloading operations. Also, it may be beneficial to revisit the particular design of this latching mechanism.

Insufficient CR8 personnel: One particular technician is required to work on the MLRS power electronics. The interview group felt that the number of these individuals available were too few. This, it was felt, contributed to two possible accident scenarios. First, the currently trained technicians were overworked which resulted in a higher frequency of the individuals experiencing fatigue. This fatigue potentially contributes to a higher incident of accidents involving CR8 personnel. The second scenario involves inadequately trained service members attempting to repair equipment. Because of the demand for the CR8 personnel, some repairs require waiting substantial lengths of time to be made. In order to meet mission objectives, occasionally insufficiently trained individuals attempt to implement these repairs. It was the consensus of the group that increasing the number of CR8 trained crew members would ease both of the problems.

Launcher stuck in up position: On rare occasion the MLRS launcher will become stuck in the up position. This usually occurs when the launcher has been raised to it's extreme up position. When this situation occurs the current procedure for unsticking the launcher is to hold it up with a crane and to disconnect the launcher hydraulic system. This can only be accomplished by sending a crew member underneath the launcher while it is being suspended by the crane. A crane failure at this point would result in a certain fatality. It was the consensus of the interview group that this procedure would benefit from some addition safety procedures and mechanism.

Annual service requires greasing while rotating: Annual service of the launcher rotating system requires a crew member to lay on top of the rotating mechanism and apply grease at several points. A number of the individuals interviewed expressed concern at performing this operation and felt different procedures were justified.

3.5 HEMTT (M977, M978, and M985)

3.5.1 Results From 285-1 Analysis

3.5.1.1 Problem Area: Following Too Close/Speeding

	DA Form 285-1 Data (n=7)	Estimated for 1985 (n=19)	Estimated for 1981-87 (n=153)
Accidents	2	5	44
Injuries	2	5	44
Fatalities	0	0	0
Injury Cost	$940	$2,540	$20,888
Damage Cost	$28,240	$76,324	$627,555
Total Cost	$29,180	$78,864	$648,443
Average Cost	$14,590	$15,772	$14,737

Description: Vehicle operated at a speed in excess to that which would reflect adequate allowance for safe operation under existing conditions, in particular, with regard to maintenance of sufficient distance from preceding vehicle.

Hazard: Excess speed causes vehicle operators to be unable to respond quickly and appropriately so as to adjust to changing driving conditions, for example, the preceding vehicle stopping abruptly. Results in loss of control of vehicle with subsequent injury and damage.

Cause:

1. Inadequate Self-Discipline (Overconfidence, Inattention) (100%)

   Example - Service member was driving HEMTT on a test course, entered a curve, began to slide, and overturned the vehicle. Similar sliding had been experienced on previous laps, but the service member failed to slow down.

3.5.1.2 Problem Area: Road Crossing/Intersection/Turning

	DA Form 285-1 Data (n=7)	Estimated for 1985 (n=19)	Estimated for 1981-87 (n=153)
Accidents	2	5	44
Injuries	4	11	89
Fatalities	1	3	22
Injury Cost	$47,120	$127,351	$1,047,111
Damage Cost	$163,000	$440,540	$3,622,222
Total Cost	$210,120	$567,891	$4,669,333
Average Cost	$105,060	$113,578	$106,122

Description: Failure of HEMTT drivers to respond adequately when passing through or turning at intersections or crossing roads.

Hazard: Rear end and broad side collisions when distances/speeds are misjudged.

Causes:

1. Inadequate Direct Supervision (50%)

   Example - Service member failed to yield the right-of-way to a motorcycle at an intersection, struck the motorcycle, and killed the motorcycle operator. The Truck Commander riding as a passenger in the vehicle failed to ensure that the driver followed appropriate safe procedures at the intersection.

2. Inadequate Unit Training (25%)

   Example - Service member failed to come to a stop and check for traffic in both directions before crossing a highway while driving in a four-vehicle convoy. As a result, the vehicle was struck by a flat-bed truck. Unit training on the local supplement to AR 385-14 had indicated that the supplement requirement for road guards when more than one vehicle is negotiating a road crossing applied only to track vehicles, rather than also to wheeled vehicles.

3. Inadequate Self-Discipline (Motivation) (25%)

   Example - Service member in the previous example failed comply with general rules and regulations, and only "glanced" for cross traffic while proceeding to cross the highway.

3.5.1.3 Problem Area: Backing

	DA Form 285-1 Data (n=7)	Estimated for 1985 (n=19)	Estimated for 1981-87 (n=153)
Accidents	1	3	22
Injuries	1	3	22
Fatalities	0	0	0
Injury Cost	0	0	0
Damage Cost	$1,650	$4,459	$36,666
Total Cost	$1,650	$4,459	$36,666
Average Cost	$1,650	$1,486	$1,666

Description: Driver takes inappropriate action to back vehicle in unsafe manner, for example, failing to use a ground guide as prescribed by procedures.

Hazard: Failure to see other vehicle or person leading to collision with vehicle and/or injury to personnel.

Cause:

1. Inadequate Self-Discipline (Motivation) (100%)

   Example - Service member was backing vehicle (without a trailer) in the trackline area with one ground guide at the left rear of the vehicle. While backing and turning left, the right front of the vehicle struck a parked truck. Service member was in a hurry to complete work and get off duty, so did not take the time to find a second ground guide as required by procedures.

3.5.1.4 Problem Area: Parking

	DA Form 285-1 Data (n=7)	Estimated for 1985 (n=19)	Estimated for 1981-87 (n=153)
Accidents	1	3	22
Injuries	1	3	22
Fatalities	0	0	0
Injury Cost	0	0	0
Damage Cost	$750	$2,027	$16,666
Total Cost	$750	$2,027	$16,666
Average Cost	$750	$675	$757

Description: While attempting to park or exit parking place, driver misjudges distance to object or other vehicle, colliding with it.

Hazard: Primarily consists of damage and light injury (for example, whiplash) from collision.

Cause:

1. Inadequate Self-Discipline (Inattention) (100%)

   Example - Service member using a ground guide parked the vehicle and the trailer being pulled on the side of a hard packed gravel road. Later, again using a ground guide, the service member started to move the vehicle from its parked position, but the right side of the vehicle slid off the shoulder of the road coming to rest against trees. Service member had not paid attention to how close the vehicle was to the steep shoulder when parking.

3.5.1.5 Problem Area: Blackout Driving

	DA Form 285-1 Data (n=7)	Estimated for 1985 (n=19)	Estimated for 1981-87 (n=153)
Accidents	1	3	22
Injuries	1	3	22
Fatalities	0	0	0
Injury Cost	0	0	0
Damage Cost	$1,951	$5,272	$43,355
Total Cost	$1,951	$5,272	$43,355
Average Cost	$1,951	$1,757	$1,970

Description: Driving at night with limited natural light and only blackout lights substantially reduces visibility.

Hazard: Reduced visibility can lead to the moving vehicle striking stationary vehicles or objects, particularly in a tactical environment off main roads.

Cause:

1. Inadequate Self-Discipline (Overconfidence) (100%)

   Example - Service member, driving the vehicle with blackout drive, turned from a tank trail onto a main highway and struck the end of a bridge railing. Service member was overconfident in his ability to see obstacles in the low visibility environment.

3.5.2 Results From Field Data Collection

3.5.2.1 Confirmation of 285-1 Identified Problem Areas

For the HEMMT, two problem areas identified in the 285-1 data analysis were targeted for investigation in the field visits. They were:

- Following too closely/speeding and
- Road crossing/turning/intersection.

Each of these problem areas were confirmed during the site interviews. It was the consensus of the groups interviewed that both of these problem areas resulted from a lack of appreciation for the size of the vehicle and insufficient training.

3.5.2.2 Additional Identified Problem Areas

The following items of interest were raised during the interview session for the HEMMT.

Loss of brakes because of low air pressure: The HEMMT braking system is designed so that a loss of pneumatic pressure will cause the brakes to fail

in an applied position. However, several of the members of the interview group described a situation where the pneumatic pressure became low enough to render the brakes inoperable, but not to lock them up (as designed to do). A few of the individuals interviewed had personally experienced this situation. One of the individuals described a situation where he had to drive some distance (5 to 10 miles) back to a repair facility without functioning brakes. All members of the interview group felt this problem should be investigated further (there was not a clear understanding of how it occurs) and that additional procedures were needed to deal with the situation when it did occur.

Jacking up the vehicle to change tires: Although no particular problem areas were associated with jacking the HEMMT, a number of individuals expressed concern at the operation. It was felt the tools available for this operation were not sufficient for the task.

Inappropriate modification of the Dash 10 document: A majority of the individuals interviewed indicated the Dash 10 service manuals had been modified as the uses of the HEMMT (variations in configuration) increased. However, these modifications to the manuals had become specialized to the various configurations. This specialization had caused critical information to be excluded from later editions of the manual. Several of the group members retained outdated manuals in order to maintain access to this information. Current versions of the manuals required crew members to look in several manuals (not always with apparent associations) to find complete operating procedures.

3.6 CUCV (M1007, M1008, M1008A, M1009, M1010, M1028)

3.6.1 Results From Field Data Collection

3.6.1.1 Problem Area: Following Too Close/Speeding

	DA Form 285-1 Data (n=95)	Estimated for 1985 (n=254)	Estimated for 1981-87 (n=1100)
Accidents	28	76	326
Injuries	543	116	500
Fatalities	3	8	35
Injury Cost	$6,360	$17,189	$73,953
Damage Cost	$127,341	$344,164	$1,480,709
Total Cost	$133,701	$361,353	$1,554,662
Average Cost	$4,775	$4,754	$4,768

Description: Vehicle operated at a speed in excess to that which would reflect adequate allowance for safe operation under existing conditions, in particular, with regard to maintenance of sufficient distance from preceding vehicle.

Hazard: Excess speed causes vehicle operators to be unable to respond quickly and appropriately so as to adjust to changing driving conditions, for example, the preceding vehicle stopping abruptly. Results in loss of control of vehicle with subsequent injury and damage.

Causes:

1. Inadequate Self-Discipline (Composure, Attention, Overconfidence, Lack of Confidence, Motivation/Mood) (68%)

Example - Soldier was driving his M1008 CUCV down hill on snow covered road. Because of overconfidence in his ability to control the vehicle under adverse road and weather conditions, he misjudged his speed and skidded into the path of an oncoming vehicle and collided with that vehicle.

2. Inadequate Experience (14%)

Example - Driver of M1008 CUCV, who had little experience with this vehicle, misjudged his speed and therefore failed to maintain appropriate distance from the vehicle he was following. As a result, he smashed into the trailer of the vehicle he was following.

3. Inadequate Unit Training (7%)

Example - Soldier driving an M1008 CUCV, because of inadequate unit training with adverse weather conditions, misjudged speed/distance in attempting to stop in icy conditions. As a result he slid into the rear end of POV, damaging both vehicles.

4. Inadequate Direct Supervision (4%)

Example - Senior occupant of vehicle, M1009 CUCV, demonstrating inadequate supervision, allowed driver to drive faster than the posted speed limit. As a result, when a second car appeared and the driver had to swerve to avoid collision, the driver did not have time to apply his breaks before loosing control of the vehicle.

5. Insufficient Information (7%)

3.6.2 Results From Field Data Collection

3.6.2.1 Confirmation of 285-1 Identified Problem Areas

For the CUCV, for problem areas tested from the 285-1 data analysis were targeted for investigation in the field visits. They were:

- Following too closely/speeding,
- Impaired driving,
- Backing, and
- Off road travel.

Each of these problem areas were confirmed during the site interviews, but it was felt that the vehicle itself did not fundamentally contribute to these problem areas. It was the consensus of the groups interviewed that each of these problem areas were essentially problem areas associated with any vehicle. For one particular configuration, the M1028, an undesirable weight distribution did aggravate the problems of following too closely and off road travel. The group felt the load under this configuration was excessive for this vehicle and caused an unusually high center of gravity for the vehicle. It was felt that this weight was too much for the vehicle braking system to adequately handle. Furthermore, the high center of gravity caused a significantly increased potential for roll over during off road travel. All of the individuals interviewed felt that increased training for the M1028 configuration would be helpful.

3.6.2.2 Results From Field Data Collection

The following items of interest were raised during the interview session for the CUCV.

No climbing steps or standing areas for deploying camouflage nets: The only undocumented problem area identified for this vehicle was the absence of climbing or standing areas on the surface of the vehicle that could be used for deploying nets. Furthermore, no regions of the vehicle surface had no-skid coatings to facilitate net deployment in inclement weather. The site visit involved viewing approximately five CUCV vehicles. Each of these vehicles had physical damage to the surface caused by personnel climbing on the vehicle to deploy nets.

3.7 RESULTS OF SUMMARY AND VALIDATION ANALYSIS

In order to evaluate whether the detailed analysis of problem areas (which utilized data from DA Form 285-1) was truly representative of all new vehicle accidents, additional analysis sought to test the generality of those conclusions. A sample of DA Form 285 data was selected, stratified by vehicle and year, for the 1981-87 period. The sample included roughly the same number of accidents per vehicle as were used in the original analysis, and the

accidents chosen were temporally spaced by choosing every nth accident for each vehicle, n being chosen to approximate the number of accidents available for the analysis of the DA Form 285-1 data.

The DA Form 285 narrative information contained in the ASMIS was then evaluated in terms of the occurrence of problem areas identified in the more detailed DA Form 285-1 narrative data. In general, the results of this analysis, shown in Table 3.2, support those from the DA Form 285-1 data. For the HEMTT and Bradley Fighting Vehicle, 87 percent (13/15) of the accidents in the validation sample demonstrated problem areas identified in the original analysis. Similar calculations resulted in 90 percent (33/37) for the M1 tank, and 100 percent for the HEMTT (7/7), and 89 percent for the CUCV (86/97).

The pattern of problem areas was also found to be in keeping with the original analysis. For the M1 tank the same three problem areas, "crushing in turret," "maintenance," and "traveling over rough terrain," once again had the highest frequency of occurrence. For the Bradley Fighting Vehicle, 4 of the 7 problem areas found in the detailed analysis were primary contributors in the sample. They were: "mounting/dismounting," "traveling on rough terrain," "maintenance," and "turret crushing."

The CUCV showed strong similarity in problem area identification (although 2 of the 11 original problem areas, "animals" and "road conditions," were not found in the validation sample), but there were two notable differences in frequency. The DA Form 285-1 analysis found only 6 of 95 (6 percent) accidents occurred at intersections or while turning while the frequency in the validation sample was 23 of 95 (24 percent). The other strong difference occurred in the problem area "other traveling on roads." The original analysis found only 5 of 95 (5 percent) accidents in this area while the validation analysis found 17 of 95 (18 percent) in this area.

Analysis of the HEMTT sample data resulted in 3 of 5 problem areas being found. The problem areas identified in the DA Form 285-1 analysis not found in the sample were "parking," and "blackout driving."

3.8 GENERAL COMMENTS

The following discussion is a synopsis of the comments received during the site visit interviews. The notions presented here apply to some extent to each of the new vehicles. However, each vehicle is not equally hazardous. Therefore, the significance of these comments varies somewhat with the hazardous nature of each vehicle.

Operators and crews for each vehicle indicated hazards are assumed to be associated with each vehicle and job. It was the general opinion of the individuals interviewed that these hazards are simply part of the job and they seem to accept these hazards. They indicated that an individuals perception of any particular hazard never seems to quite reach the level

possible until after they are directly involved in an accident. Self-discipline and developed habits are the principle means used as accident preventive measures. The groups indicated that some notion of an organizational experience develops with time. It is this group experience that needs to be maintained and transferred to newly assigned individuals in order to manage the hazards of any vehicle.

Because of this organizational experience, all practical vehicle training occurs at the unit. Usually this training takes the form of mentoring and individual on-the-job experiences. Furthermore, vehicle training is fundamentally different than mission training, and is currently accomplished when situations present themselves. The groups indicated that vehicle training should receive special consideration, apart from the pressures and requirements of mission training. In addition, this training should concentrate on presenting realistic problem situations, rather than simple basic vehicle maneuvers.

As various broad purpose vehicles (HEMMT, CUCV, HMMWV, etc.) are expanded into new uses and configurations, the maintenance documentation undergoes a similar refocusing of information. Various groups interviewed indicated that these changes in the documentation often follow the new uses of the vehicles, and sometimes loses track of the maintenance information needs of the basic vehicle. It was felt that additional effort was needed to preserve fundamental vehicle information. Furthermore, comments were made regarding the overall focus of the maintenance documentation. A number of individuals indicated that the maintenance documentation should be expanded to include problem solving information in addition to the current trouble-shooting content of the documents.

TABLE 3.2. Comparison of Problem Frequency for DA Form 285-1 Versus DA Form 285 Data

Vehicle	Problem Area	DA Form 285-1		DA Form 285 Data	
		Frequency	Percentage Of Total	Frequency	Percentage Of Total
M1 Tank	Crushing in Turret	9	24%	6	15%
	Maintenance	6	16%	6	15%
	Traveling Over Rough Terrain	5	14%	7	18%
	Mounting/Dismounting Vehicle	2	5%	4	10%
	Crushing in Doors/Hatches	3	8%	2	5%
	Backing	2	5%	2	5%
	Handling/Use of Hoffman Devices	2	5%	0	0%
	Speeding	0	0%	2	5%
	Parking	0	0%	2	5%
	Other	8	22%	8	21%
	TOTAL	37		39	
CUCV		Frequency	Percentage Of Total	Frequency	Percentage Of Total
	Following Too Close/Speeding	28	29%	15	16%
	Impaired Driving	16	17%	8	8%
	Backing	8	8%	8	8%
	Turning/Intersection	6	6%	23	24%
	Off-Road Travel	7	7%	6	6%
	Passing	6	6%	4	4%
	Road Conditions	6	6%	0	0%
	Other Traveling on Roads	5	5%	17	18%
	Animals	3	3%	0	0%
	Parking	1	1%	1	1%
	Other	9	9%	13	14%
	TOTAL	95		95	
BFV		Frequency	Percentage Of Total	Frequency	Percentage Of Total
	Mounting/Dismounting	3	19%	3	20%
	Traveling on Rough Terrain	3	19%	3	20%
	Parking Vehicle	2	13%	0	0%
	Maintenance	2	13%	2	13%
	Turret Crushing	1	6%	5	33%
	Crossing Roads	1	6%	0	0%
	Backing	0	0%	2	13%
	Other	4	25%	0	0%
	TOTAL	16		15	
HEMTT		Frequency	Percentage Of Total	Frequency	Percentage Of Total
	Following Too Close/Speeding	2	29%	2	29%
	Road Crossing/Intersection/ Turning	2	29%	2	29%
	Backing	1	14%	1	14%
	Parking	1	14%	0	0%
	Blackout Driving	1	14%	0	0%
	Off Road/Bad Road	0	0%	1	14%
	TOTAL	7		7	

4.0 DISCUSSION AND CONCLUSIONS

4.1 SUMMARY OF HUMAN ERROR ACCIDENTS

The above discussion described specific problem areas and the associated system inadequacies for each of the new vehicles for human error-caused accidents. The problem areas are summarized in Table 4.1 for new wheeled and new tracked vehicles. The major problem area for wheeled vehicles is following too-close/speeding. It accounts for 29 percent of the 285-1 reported new wheeled vehicle accidents and 36 percent of the injuries with an estimated cost for the seven-year period of $2,183,105. Among possible explanations for the frequency of occurrence of this problem area are:

- Lack of familiarity with braking capabilities of the vehicles
- Desire to test the capabilities of the new vehicle
- Improper training, leading operators to believe the system is more capable (safe, stable, able to brake more quickly) than it actually is.

The second largest problem area is impaired driving (alcohol/drugs and fatigue) accounting for 16 percent of the accidents and injuries with an estimated cost for the seven-year period of $1,069,081. This problem area is probably not directly related to the fact that these vehicles are new because it is self-generated by the individual involved, not by the vehicle. The intersection/turning/road crossing area has a very high estimated seven-year cost primarily because of one HEMTT accident resulting in a large cost and a fatality (case number 850801018).

For track vehicles, the largest problem areas are turret crushing, maintenance, and traveling on rough terrain accounting for 24, 19, and 19 percent respectively of the total 285-1 reported accidents and 16, 14, and 17 percent, respectively, of injuries; with estimated seven-year costs of $544,434, $863,282, and $43,954, respectively. Most of these costs are associated with injuries rather than damage because of the nature of the problem areas. Therefore, total costs for accidents in these problem areas will not be as large as for accidents in which the vehicle can sustain considerable damage. For example, the large costs estimated for the backing problem area reflect, in part, a single accident in which one M1 backed into another causing over one million dollars in damage (case number 850321001).

Each of these three largest problem areas could result at least partially from the vehicles being new. Turret crushing accidents may result from personnel being unfamiliar with the operation of the turret and the potential hazard. Accidents in the maintenance area may occur for similar reasons.

TABLE 4.1. New Vehicle Accidents/Injuries by Problem Area (DA Form 285-1 Reports)

Wheeled Vehicles				
Problem Area	CUCV	HEMTT	Total	Estimated 7-Year Total Cost
Following Too Close/ Speeding	28/43	2/2	30/45	$2,183,105
Impaired Driving	16/20	-	16/20	$1,069,081
Backing	8/9	1/1	9/10	$124,224
Turning/ Intersections	6/5	2/4	8/9	$4,928,391
Off-Road Travel	7/7	-	7/7	$222,430
Passing	6/5	-	6/5	$183,569
Road Conditions	6/8	-	6/8	$181,418
Other Traveling On Roads	5/6	-	5/6	$839,452
Animals	3/3	-	3/3	$120,174
Parking	1/1	1/1	2/2	$29,759
Blackout Driving	-	1/1	1/1	$43,355
Other	9/8	-	9/8	$482,615
TOTAL	95/115	7/9	102/124	$10,407,573

Tracked Vehicles				
Problem Area	M1 Tank	BFV	Total	Estimated 7-Year Total Cost
Crushing In Turret	9/9	1/1	10/10	$544,434
Maintenance	6/8	2/1	8/9	$863,282
Traveling Over Rough Terrain	5/6	3/5	8/11	$43,954
Mounting/ Dismounting Vehicle	2/2	3/3	5/5	$153,069
Crushing In Door/Hatches	3/5	-	3/5	$621,111
Backing	2/4	-	2/4	$17,887,416
Handling/Use Of Hoffman Devices	2/2	-	2/2	$16,527
Parking Vehicle	-	2/5	2/5	$163,218
Crossing Roads	-	1/1	1/1	$185,034
Other	8/7	4/4	12/11	$1,960,670
TOTAL	37/43	16/20	53/63	$22,438,715

Accidents in rough terrain may be associated with the increased speed and handling available in the new vehicles versus the vehicles they replaced, and the desire to use this enhanced capability in tactical training.

Tables 4.2 and 4.3 summarize the system inadequacies associated with these problem areas. Inadequate self-discipline, i.e., self-generated causes of accidents, including inattention, overconfidence, motivation/attitude, underconfidence, and use of drugs/alcohol, accounted for 57 percent of the system inadequacies causing or contributing to new wheeled vehicle accidents and 38 percent of the system inadequacies for track vehicles. The other most prevalent system inadequacies are inadequate experience and fatigue for wheeled vehicles and inadequate unit training for track vehicles. Among these system inadequacies, inadequate training and inadequate experience are most likely to be associated with the vehicles being new.

Jacking up the vehicle to change tires: Although no particular problem areas were associated with jacking the HEMMT, a number of individuals expressed concern at the operation. It was felt the tools available for this operation were not sufficient for the task.

Inappropriate modification of the Dash 10 document: A majority of the individuals interviewed indicated the Dash 10 service manuals had been modified as the uses of the HEMMT (variations in configuration) increased. However, these modifications to the manuals had become specialized to the various configurations. This specialization had caused critical information to be excluded from later editions of the manual. Several of the group members retained outdated manuals in order to maintain access to this information. Current versions of the manuals required crew members to look in several manuals (not always with apparent associations) to find complete operating procedures.

4.2 ENVIRONMENTAL CONDITIONS

Analysis of environmental conditions examined two sets of accident cases For each set, accidents were tabulated in terms of injuries, fatalities, and injury and damage costs. The first set, consisting of those cases for which DA Form 285-1 was provided, was examined in order to be comparable to analysis of task-based problem areas. A second set, consisting of all 1985 accidents resident in the ASMIS, was assembled in order to have a larger sample upon which to base projections.

TABLE 4.2. New Wheeled Vehicle (CUCV, HEMMT) System Inadequacies by Problem Area (285-1 REPORTS)

	SYSTEM INADEQUACY CODES*											
	ISD	01	02	03	09	12	13	16	21	23	97	TOTAL
Following Too Close/Speeding	21	--	2	4	--	--	--	--	--	1	2	30
Passing	6	--	--	--	--	--	--	--	--	--	--	6
Intersection/Turning	4	--	1	--	--	1	--	--	1	2	1	10
Other Traveling on Roads	2	--	--	3	--	1	--	--	--	--	--	6
Off-Road Travel	2	1	2	2	--	1	--	--	--	1	--	9
Backing	9	--	--	--	--	--	--	--	--	--	--	9
Impaired Driving	8	--	--	--	9	--	--	--	--	--	--	17
Road Conditions	--	--	2	2	--	--	1	1	--	--	2	8
Animals	3	--	--	1	--	--	--	--	--	--	--	4
Parking	2	--	--	--	--	--	--	--	--	--	--	2
Blackout Driving	1	--	--	--	--	--	--	--	--	--	--	1
TOTAL	58	1	7	12	9	3	1	1	1	4	5	102

* System Inadequacy Codes

ISD - Inadequate self-discipline (includes inadequate composure, inadequate attention, overconfidence, lack of confidence, inadequate motivation/mood, effects of alcohol/drugs).
01 - Inadequate school training.
02 - Inadequate unit training.
03 - Inadequate experience.
09 - Fatigue.
12 - Environmental conditions.
13 - Inadequate facilities or services.
16 - Inadequate maintenance.
21 - Inadequate supervision/coordination by unit command.
23 - Inadequate supervision/coordination by direct supervisor.

TABLE 4.3. New Track Vehicle (M1 Tank, M2/3 BFV) System Inadequacies by Problem Area (285-1 REPORTS)

	SYSTEM INADEQUACY CODES*												
	ISD	02	03	09	11	12	14	17	18	21	23	97	TOTAL
Turret Crushing	6	--	2	--	1	--	--	--	1	--	--	--	10
Door/Hatch Crushing	1	1	1	--	--	--	--	--	--	--	--	--	3
Traveling on Rough Terrain	2	2	--	2	1	1	--	--	--	--	--	1	9
Road Crossing	1	--	--	--	--	--	--	--	--	--	--	--	1
Backing	1	--	--	--	--	--	--	--	1	--	--	--	2
Parking	2	--	--	--	--	--	--	--	--	--	--	--	2
Mounting/Dismounting	3	1	--	--	--	--	--	--	--	--	1	--	5
Maintenance	2	1	1	1	1	--	1	2	--	--	--	--	9
Handling/Use of Hoffman Devices	--	2	--	--	--	--	--	--	--	--	--	--	2
Other	3	3	2	1	1	--	--	--	--	2	--	--	12
TOTAL	21	10	6	4	4	1	1	2	2	2	1	1	55

* System Inadequacy Codes

ISD - Inadequate self-discipline (includes inadequate composure, inadequate attention, overconfidence, lack of confidence, inadequate motivation/mood, effects of alcohol/drugs).
02 - Inadequate unit training.
03 - Inadequate experience.
09 - Fatigue.
11 - Habit interference.
12 - Environmental conditions.
14 - Equipment/materiel improperly designed/not provided.
17 - Improper use of tool/equipment/materiel.
18 - Inadequate written procedures for operation under normal conditions.
21 - Inadequate supervision/coordination by unit command.
23 - Inadequate supervision/coordination by direct supervisor.

Building on the results of the DA Form 285 analyses, Table 4.4 also shows projections for the 1981-87 period of the impacts of accidents in which the presence of environmental conditions could be expected. These projections are based the proportion of accidents in the 1985 DA Form 285 data in which environmental conditions were present. This same proportion was used in conjunction with the numbers of accidents for each vehicle found for the entire 1981-87 data for new vehicles and the average cost of accidents found in 1985 to project total numbers of accidents, injuries, and costs for the full seven-year span.

The impact of environmental conditions is clearly substantial. The data recorded from the DA Form 285-1 narrative show, across vehicles, the presence of environmental conditions in 19.6 percent of all accidents. ASMIS data show the presence of environmental conditions in 35.8 percent of the 1985 accidents with a total cost of $1,945,030. Projecting the ASMIS findings to all new vehicle accidents for the 1981-87 time frame results in 710 accidents with 753 injuries, 13 fatalities, and total injury and damage costs of $10,752,224.

4.3 MATERIEL FAILURES

Four accidents caused by materiel failures were investigated by safety personnel. Five materiel failures were identified; however, two of the accidents were caused by similar materiel failures. Two system inadequacies associated with materiel failures were identified: 1) Inadequate design, and 2) Maintenance or inspections failed to detect defective or damaged components.

Inadequate design was identified in as a probable cause factor in two of the four failures reviewed. The systems that were inadequately designed included the M1 electrical system and the M1 optical fire sensor. The electrical system design inadequacy, i.e. the lack of an electrical current overload device, allowed the electrical system to short creating a fire in the engine compartment and in the round ready rack. The optical fire sensor's failure to detect the fire in the engine compartment was also attributed to a design inadequacy. That is, the sensor failed to operate properly in a Class A/B fire.

Maintenance or inspection failure to detect defective or damaged components was determined to be the probable cause in the other two materiel failure accidents. In both cases materiel failures were identified as the probable cause; however, the damaged or defective components should have been detected and replaced during maintenance or inspection activities. The failed components identified include the M1009 service brakes and an M1 track block pin. Both failures resulted in a loss of control of the vehicle because of brake lock up and track disconnect.

TABLE 4.4. Environmental Conditions

MLRS (M270)

	DA Form 285-1 Data (n=0)	DA Form 285 Data For 1985 (n=5)	Estimated for 1981-87 (n=14)
Environmental Accidents	0	1	3
Injuries	0	1	3
Fatalities	0	0	0
Injury/Cost	0	0	0
Damage/Cost	0	$2,975	$8,333
Total/Cost	0	$2,975	$8,333
Average Cost	0	$2,975	$2,777

M1 Tank

	DA Form 285-1 Data (n=37)	DA Form 285 Data For 1985 (n=88)	Estimated for 1981-87 (n=517)
Environmental Accidents	5	30	176
Injuries	8	29	170
Fatalities	0	0	0
Injury/Cost	$3,320	$26,710	$157,117
Damage/Cost	$1,286,894	$1,329,523	$7,820,723
Total/Cost	$1,290,214	$1,356,233	$7,977,840
Average Cost	$258,042	$45,207	$45,328

TABLE 4.4. Environmental Conditions (Cont'd)

Bradley Fighting Vehicle (M2/3)

	DA Form 285-1 Data (n=16)	DA Form 285 Data For 1985 (n=34)	Estimated for 1981-87 (n=133)
Environmental Accidents	3	8	39
Injuries	5	8	39
Fatalities	0	0	0
Injury/Cost	$750	$46,390	$250,756
Damage/Cost	$38,994	$128,763	$627,016
Total/Cost	$13,248	$175,153	$946,772
Average Cost	$13,248	$19,461	$19,321

CUCV

	DA Form 285-1 Data (n=95)	DA Form 285 Data For 1985 (n=254)	Estimated for 1981-87 (n=1100)
Environmental Accidents	21	90	391
Injuries	23	122	530
Fatalities	3	3	13
Injury/Cost	$3,220	$28,295	$123,021
Damage/Cost	$50,034	$316,324	$1,375,321
Total/Cost	$53,254	$344,619	$1,488,342
Average Cost	$2,535	$3,829	$3,832

TABLE 4.4. Environmental Conditions (Cont'd)

HEMTT (M977, M978, M987)

	DA Form 285-1 Data (n=7)	DA Form 285 Data For 1985 (n=19)	Estimated for 1981-87 (n=153)
Environmental Accidents	2	7	56
Injuries	2	4	32
Fatalities	0	0	0
Injury/Cost	0	$2,710	$21,854
Damage/Cost	$3,451	$30,464	$245,677
Total/Cost	$3,451	$33,174	$267,531
Average Cost	$1,725	$4,739	$4,777

HMMWV

	DA Form 285-1 Data (n=0)	DA Form 285 Data For 1985 (n=14)	Estimated for 1981-87 (n=141)
Environmental Accidents	0	9	90
Injuries	0	12	120
Fatalities	0	0	0
Injury/Cost	0	$1,490	$14,900
Damage/Cost	0	$31,386	$313,860
Total/Cost	0	$32,876	$313,860
Average Cost	0	$3,652	$3,652

The following discusses the system inadequacies associated with the materiel failures.

4.3.1 Inadequate Design

M1	
# of Accidents	2
# of Design Inadequacies	3
Injuries	3
Fatalities	0
$ Injury	0
$ Damage	1,084,956
$ TOTAL	1,084,956

Description: Because of the lack of a current overload device in the M1, there are no mitigative or preventive measures to preclude electrical shorts in the electrical wiring harness.

Description: Because of the contaminants and by-products generated during a Class A/B fire, the optical fire sensor may be unable to detect the fire and activate the automatic fire suppression system.
Hazard: Electrical shorts in the wiring harness can create extreme temperatures and ignite available fuel sources.

Example: Electrical wires in a steel conduit shorted creating a fire in the electrical conduit. The fire burned a hole in an unshielded fuel cell and ignited the fuel.

Example: Electrical wires shorted between the slipping and the turret network box creating a fire. The resulting fire burned three rounds in the round ready rack.

Example: Because of the positioning or the design of the optical fire sensor, the sensor failed to detect the fire in the engine compartment or activate the automatic fire suppression system. The optical fire sensor failed to operate because of the contaminants and by-products generated by a Class A/B fire, allowing the fire created by a short in the electrical system to continue to burn, burning a hole in an unshielded fuel cell and igniting the fuel.

4.3.2. Maintenance or Inspections Fail to Detect Failed or Defective Components

M1009	
Damaged or Defective Components	1
Injuries	1
Fatalities	0
$ Injury	970
$ Damage	3000
$ TOTAL	3970

M1	
Damaged or Defective Components	1
Injuries	0
Fatalities	0
$ Injury	0
$ Damage	9,200
$ TOTAL	9,200

Description: Because of inadequate maintenance or inspection, components that are manufactured improperly (i.e. defective) or damaged during use may fail if not identified and replaced during maintenance and inspection activities.

Example: Defective brakes on an M1004 not detected during preventative maintenance and vehicle inspection locked up causing the operator to lose control of the vehicle. The brakes locked up when applied at a high rate of speed.

Example: Damage or defective track block pin on an M1 was not detected during routine maintenance or inspection, failed during vehicle operation. This failure resulted in a track disconnect and a loss of vehicle control.

4.3.3 Comparison of DA Form 285-1 Results to DA Form 285 Data

The ASMIS 285 accident data were analyzed for the seven year period to determine the extent of these materiel failures and to identify any EIRs that have been submitted that may address these failures.

Five electrical system materiel failures or six percent of the total M1 materiel failures were identified for the M1 tank that could have been caused by an electrical short. No EIRs were submitted addressing any of the failures.

The average damage cost of an electrical system failure was $134,500. Two failures were identified for the fixed fire suppression system; however, it

was impossible to determine if the failures referred to the availability of the optical sensor.

Eight materiel failures or 22 percent of the total CUCV materiel failures were identified for the CUCV braking system. One EIR (# DG5064/1) was submitted for CUCV brake system materiel failures. The average damage cost associated with a failure of the brake system was $2370.

Four of the nine track failures could have been caused by track block pin shear. The failures were identified as failures of the track and the failure mode or cause was shearing. These four failures resulted in $16,200 damage or an average of $4,050 per failure. No EIR's have been submitted addressing track block pin failures. These failures may occur during normal use and may not be addressed in an EIR.

4.4 ANALYSIS OF DA FORM 285 MATERIEL FAILURES

The following is an analysis of the ASMIS 285 data with respect to materiel failures identified by vehicle. There were 274 reported materiel failures for the seven year period. These materiel failures have been summarized and are shown in Table 4.5. Four EIR's were submitted during this period including one for the M1 stowage racks, one for the BFV chassis,one for the HEMTT braking system, and one for the CUCV braking system. There were no materiel failures identified in the coded data for the MLRS. There were a total of 79 materiel failures identified for the M1, 13 for the BFV, six for each of the HEMTT and the HMMWV and 38 for the CUCV.

Most of the failures were caused by the movement of the vehicle, i.e. vibration, shaking and chaffing, and rubbing. Several failures were caused by severed, pulled, sheared or cut components. However, except in those failures involving fuel lines or electrical wires, it was impossible to determine if the mounting brackets failed or if the components failed because of these causes. A review of the failure data indicated that the electrical system failed or caused a failure in 10 of the reported materiel failures. This was the only system identified that could fail or malfunction causing a failure of an adjacent component. One hatch failure (BFV) was reported for all vehicles with hatches.

The majority of the M1 materiel failures, 17 of the 79, identified failed fuel systems. These failures were attributed to fuel cells or lines (7), fuel systems not elsewhere coded (NEC) (7), fuel pumps (2) and filters (1). Failures of the fuel system were caused by worn components, sheared or rubbed fuel lines or cells, punctures, cuts, and electrical malfunctions. The braking system was identified in 10 of the reports and accounted for $1,518,116 damage costs. However, identifying the causes of the failures was not possible because of a lack of information, i.e. seven unreported causes. The electrical system was identified in nine of the accidents representing $1,210,487 damage costs.

TABLE 4.5. Summary of Materiel Failures by Vehicle for the CY 1981 - 1987

VEHICLE	MATERIEL FAILED	NUMBER OF FAILURES	FAILURE MODE OR CAUSE DESCRIPTION	NUMBER	DAMAGE COST	AVERAGE COST	EIR SUBMITTED
MLRS							
M270	UNREPORTED	1			1290		
TOTAL		1			1290		
M1							
M1/M1A1	STOWAGE RACKS	1	SHAKEN	1	0		LW1313/1
	BODY NEC	2	SEVERED	1	1000		
			UNREPORTED	1	0		
SUBTOTAL		3			1000	333	
	HYDRAULIC BRAKE SYSTEM	4	RUPTURE	2	737000		
			UNREPORTED	2	375053		
	BRAKE LINE	1	RUBBED	1	5850		
	PARKING BRAKE	4	UNREPORTED	4	43500		
	FITTINGS/SEALS	1	UNREPORTED	1	350053		
SUBTOTAL		10			1510116	151000	
	HATCHES	8	VIBRATION	2	0		
			UNREPORTED	6	0		
SUBTOTAL		8			0		
	BATTERIES	1	OVERHEATED	1	6306		
	LIGHTS	1	UNREPORTED	1	3106		
	SWITCHES	1	UNREPORTED	1	3628		
	WIRING HARNESS	1	RUBBED	1	108972		
	COMMUNICATIONS	3	PULLED	1	0		
			UNREPORTED	2	3525		
	ELECTRICAL NEC	2	OVERHEATED	1	585950		
			ELECTRICAL	1	499000		
SUBTOTAL		9			1210487	134500	
	ENGINE NEC	6	VIBRATION	1	12587		
			RUBBED	1	300000		
			RUPTURE	2	254033		
			UNREPORTED	2	560620		
SUBTOTAL		6			577794	96300	
	FUEL FILTER	1	UNREPORTED	1	1370		
	FUEL PUMP	2	WORN	1	984		
			UNREPORTED	1	1260		
	FUEL CELLS/LINES	7	RUBBED	1	9999		
			PULLED	1	2100		
			SHEARED	2	15618		
			UNREPORTED	3	177040		
	FUEL SYSTEMS NEC	7	VIBRATION	7	297157		
			PUNCTURED	1	10000		
			CUT	1	434000		
			ELECTRICAL	1	20000		

TABLE 4.5. Summary of Materiel Failures by Vehicle for the CY 1981 - 1987 (Cont'd)

VEHICLE	MATERIEL FAILED	NUMBER OF FAILURES	FAILURE MODE OR CAUSE DESCRIPTION	FAILURE MODE OR CAUSE NUMBER	DAMAGE COST	AVERAGE COST	EIR SUBMITTED
M1			UNREPORTED	3	93252		
SUBTOTAL		17			1068785	62870	
	SPECIAL PURPOSE KIT NEC	1	UNREPORTED	1	13500	13500	
SUBTOTAL		1			13500	13500	
	SHOCK ABSORBER	1	SHEARED	1	413		
SUBTOTAL		1			413	413	
	WEAPONS SYSTEMS	6	OBSTRUCTED	1	0		
			BURST	1	313201		
			UNREPORTED	4	21249		
SUBTOTAL		6			334450	39100	
	TRACK SPROCKETS	2	SHEARED	2	26400		
	TRACK	7	STRETCHED	1	0		
			SHEARED	4	16200		
			UNREPORTED	2	10		
SUBTOTAL		9			42610	4730	
	FIXED FIRE SUPPRESSION	2	ELECTRICAL	1	0		
			UNREPORTED	1	1300		
SUBTOTAL		2			1300	650	
	UNREPORTED	7			408743		
TOTAL		79			5257193	465096	
M2/M3	INTERIOR	1	VIBRATION	1	0		
SUBTOTAL		1			0		
	WATER PUMP	1	OVERHEATED	1	0		
	COOLING SYSTEM	1	UNREPORTED	1	0		
SUBTOTAL		2			0	0	
	HATCHES	1	BENT	1	1793		
SUBTOTAL		1			1793	1793	
	REGULATOR	1	CHARRED	1	2000		
	WIRING HARNESS	1	ELECTRICAL	1	1047		
	COMMUNICATIONS	1	UNREPORTED	1	1500		
SUBTOTAL		3			4547	1520	
	FRAME/CHASIS	2	UNREPORTED	2	447750		8500015
SUBTOTAL		2			447750	223900	
	DEEPWATER KIT	1	OBSTRUCTED	1	165454		
SUBTOTAL		1			165454	165454	

<u>TABLE 4.5</u>. Summary of Materiel Failures by Vehicle for the CY 1981 - 1987 (Cont'd)

VEHICLE	MATERIEL FAILED	NUMBER OF FAILURES	FAILURE MODE DESCRIPTION	OR CAUSE NUMBER	DAMAGE COST	AVERAGE COST	EIR SUBMITTED
M2/M3							
	WEAPON SYSTEM	2	VIBRATION	1	0		
			CHAFED	1	200000		
SUBTOTAL		2			200000	100000	
	UNREPORTED	1			2500		
TOTAL		13			822044	492667	
HEMTT							
	AIRBRAKE SYSTEM	1	UNREPORTED	1	1000		81D4W001
	AIRBRAKE LINE	2	UNREPORTED	2	6500		
	BRAKE SYSTEM	2	UNREPORTED	2	3534		
SUBTOTAL		5			11034	2200	
	UNREPORTED	1			0		
TOTAL		6			11034	2200	
HMMWV	PARKING BRAKE	1	UNREPORTED	1	0		
SUBTOTAL		1			0	0	
	ELECTRICAL	1	ELECTRICAL	1	1300		
SUBTOTAL		1			1300	1300	
	FRAME/CHASSIS	1	SHEARED	1	739		
SUBTOTAL		1			739	739	
	STEERING SYSTEM	1	RUBBED	1	1618		
SUBTOTAL		1			1618	1618	
	WEAPONS SYSTEM	1	UNREPORTED	1	0		
SUBTOTAL		1			0	0	
	UNREPORTED	1			8195		
TOTAL		6			11852	3657	
CUCV							
	AXLES	3	CORRODED	1	0		
			SHEARED	1	5500		
			SEVERED	1	2163		
SUBTOTAL		3			7663	2530	
	WINDSHIELD	1	SHEARED	1	0		
	RESTRAINTS	1	UNREPORTED	1	12000		
SUBTOTAL		2			12000	6000	
	MASTER CYLINDER	1	UNREPORTED	1	1213		DG5 064/1
	BRAKE SYSTEM	7	UNREPORTED	7	17738		
SUBTOTAL		8			18951	2370	

TABLE 4.5. Summary of Materiel Failures by Vehicle for the CY 1981 - 1987 (Cont'd)

VEHICLE	MATERIEL FAILED	NUMBER OF FAILURES	FAILURE MODE OR CAUSE DESCRIPTION	NUMBER	DAMAGE COST	AVERAGE COST	EIR SUBMITTED
CUCV							
	LIGHTS	1	OVERHEATED	1	3250		
	COMMUNICATIONS	1	SHEARED	1	0		
	ELECTRICAL NEC	1	OVERHEATED	1	15061		
SUBTOTAL		3			18311	6100	
	ENGINE SYSTEM	1	UNREPORTED	1	2891		
SUBTOTAL		1			2891	2891	
	FRAME/CHASIS	1	OVERPRESSURE	1	2595		
SUBTOTAL		1			2595	2595	
	THROTTLE	1	UNREPORTED	1	5432		
SUBTOTAL		1			5432	5432	
	STEERING WHEEL	1	UNREPORTED	1	2000		
SUBTOTAL		1			2000	2000	
	TRANSMISSION	1	UNREPORTED	1	4101		
SUBTOTAL		1			4101	4101	
	LUG BOLTS	1	UNREPORTED	1	1100		
	TIRES/TUBES	13	WORN	1	1200		
			BURST	8	98159		
			PUNCTURED	1	1000		
			UNREPORTED	3	12255		
	WHEELS NEC	2	CUT	1	7750		
			UNREPORTED	1	8018		
SUBTOTAL		16			129488	8100	
	UNREPORTED	1			14831	14831	
TOTAL		38			218203	56950	
GRAND TOTAL		274			6309961		

Although, it ranks number three in total failures it ranks number two total damage costs. The remaining failures can be attributed to normal use of the vehicle.

Initially, the largest losses in the BFV were due to frame or chassis failures, amounting to $447,750. However, a review of the DA 285 Narratives identified this as a failure of the trim vane. One additional failure of the deep water fording kit was identified in the ASMIS Data. These two failures resulted in $613,204 or 75 percent of the total damage costs, or $822,044. Two failures were identified for the weapons systems. These two failures account for $200,000 or 24 percent of the total damage costs. The one hatch failure identified in the accident data amounted to $1793 and failed "bent".

All HEMTT materiel failures identified in the accident data involved the braking system. Brake system failures were identified in 5 of the 6 materiel failures and accounted for all of the reported damage costs of $11,034.

Six subassembly failures were identified for the HMMWV, one each for the parking brake, electrical system, frame or chassis, steering system, and weapons system. The sixth failure did not identify a subassembly, however, it amounted to $8,195 or 70 percent of the total $11,852. Failures of the parking brake and the steering system have been identified previously in category 1 QDR'S and EIR's.

The majority of the CUCV's 38 materiel failures involved the wheels, tires and tubes. Failures of these components amounted to $129,488 or 60 percent of the total $218,203 damage. 13 of the 16 wheel, tire or tube failures were because of worn, burst or punctured tires or tubes. Similar materiel failures occurred in the CUCV as in the other vehicles, i.e., braking system, engine, electrical system, frame or chassis, or fuel system. Four additional systems were identified that may be considered CUCV specific. These included the axles, windshield, restraints (seat belts), and the transmission.

4.5 COLLISIONS LOCATIONS

The findings discussed in Sections 3.1 - 4.0 are based entirely on data reported on DA Form 285-1 for the targeted year. The analysis here supplements these finding based on data from DA Form 285 for the entire seven year period. A preliminary analysis of the data was performed to identify the more common accident locations. The results of this preliminary analysis were then used to select specific locations for additional analyses. The preliminary results in Table 4.6 show that of the 1768 fatal and non-fatal accidents occurring in the three primary locations, 927 occurred on roadways, 268 occurred in crew-served weapons training areas, 199 occurred in vehicle facilities, 112 occurred in non-firing training areas, 96 occurred on vehicle trails, 59 occurred in parking lots, and 49 occurred in Training Areas Not Elsewhere Coded (NEC). These locations represent approximately 92 percent of the fatal and non-fatal accident locations identified in the 285 accident data for the seven year period.

TABLE 4.6. Fatal and Non-Fatal Accident Locations

Accident Locations	MLRS	M1	BFY	HEMTT	HMMWV	CUCV	TOTAL
Maintenance/Fabrication							
Vehicle	2	105	30	19	5	38	199*
Other	0	0	0	1	0	0	1
NEC	1	5	3	1	0	0	10
Travelways							
Pedestrian	0	0	0	0	1	1	2
Vehicle Trail	2	28	17	13	15	21	96*
Roadway	3	50	29	59	63	732	927*
Parking Lo	0	4	3	1	2	49	59*
NEC	0	3	3	2	3	6	17
Training Areas							
Range - S/A	0	1	1	0	1	2	5
Range - C/S	2	189	64	2	4	5	266*
Non-Firing	1	24	14	13	22	38	112*
Temporary	0	4	4	0	1	6	15
EOD	0	1	1	0	0	0	2
NEC	2	21	4	6	10	6	49*
	13	435	164	118	127	904	1768
Other Areas or Not Coded	1	82	20	33	14	196	339
TOTAL	14	517	184	151	141	1100	2107

* These represent approximately 97 percent or 1710 of the 1768 Fatal and Non-Fatal accidents.

5.0 RECOMMENDATIONS

These recommendations result from an examination of the identified problem areas and associated system inadequacies. The majority of these recommendations represent additions or refinements to existing training and field operation manuals. The particular manuals of interest are specific to each vehicle. The specific identification of each appropriate document will be provided by the U.S. Army Safety Center.

5.1 M1

Crushing in Turret

1. Develop a warning ring or ridge that can be field installed inside the turret and will provide physical warning to the loader when his foot is in a hazardous position.
2. Develop additional hand holds for the loader position to utilize during travel in the standing position.

Traveling Over Rough Terrain

1. Develop additional hand-holds for the loader position to utilize during travel in the standing position.
2. Provide padding around the interior rim of the loaders hatch to protect the loader during travel over rough terrain.
3. Provide additional hand-holds for the loader position inside the turret to use during travel in the seated position.

Crushing in Doors/Hatches

1. Provide additional unit training to address the need for appropriate communication involving activities in and around the M1 hatches.
2. Establish procedure to verify the security of the loader knee switch is secure prior to working in the area of the ammunition semi-ready door.
3. Provide an interlock to prevent the ammunition ready door from opening when the semi-ready door is open.

Mounting/Dismounting

1. Supplement unit training to emphasize need to maintain three-point contact on vehicle surface.

Backing

1. Establish procedures for backing M1 in areas of limited visibility (because of obscurants, terrain, etc.) during field activities.

Load Uncouple/Recouple Auto-Realignment

1. Develop safe procedures for completing this action and provide additional unit training in these new procedures.

Towing Operations

1. Develop situation specific procedures for towing operations occurring under adverse conditions and provide additional unit training in these new procedures.

Dash 10 Describes Trouble Shooting

1. Supplement vehicle Dash 10 documents with specific guidance for problems solving techniques.

5.2 BRADLEY

Mounting/Dismounting

1. Supplement unit training to emphasize need to maintain three-point contact on vehicle surface.

Traveling Over Rough Terrain

1. Establish procedure which provide guidance regarding acceptable movement (such as required to restow particular equipment within the loader/observer area during rough terrain travel.
2. Improve communications equipment and capability throughout the vehicle.

Turret Crushing

1. Develop procedures for communication between crew members in the turret and the crew members in the loader/observer area for those circumstances when electronic communications systems are inoperable.
2. Provide a procedure for verifying the operability of communications equipment and the reception of required turret announcements, prior to applying turret power.

5.3 HMMWV

Impaired Vision

1. Relocate vehicle mirrors forward to improve their visibility to the driver.
2. Provide additional unit training in compensating for the blind spot at intersections and road crossings.

Seat Belt Operation

1. Provide additional warnings in the training and operations documentation regarding the unique operation of the seat belts.

Window Drop

1. Provide additional warning in the training and operations documentation regarding this hazard.
2. Provide procedures for securing the window in the up position.

5.4 MLRS

Tarp Covering Contributing to Falls

1. Eliminate the use of a complete launcher covering tarp, and replace with a smaller tarp specifically designed to cover sensitive equipment only.

Tilt Forward Cab

1. Develop a procedure for inspecting the cab restraint system for integrity at sensitive points in the cab tilting process.

Pod Latch Handle Sudden Release

1. Provide additional warnings in the operations manuals regarding control of the pod latching handle during releasing operations.

Insufficient CR8 Personnel

1. Provide additional training to qualify more personnel in the CR8 specialty.

Launcher Stuck in Up Position

1. Provide additional procedures for protecting against launcher drop while undergoing repair activities.

Launcher Annual Service

1. Review annual servicing procedures and develop modified procedures for hazardous servicing activities.

5.5 HEMMT

Following Too Close/Speeding

1. Provide additional unit training in vehicle operation under adverse conditions.

Loss of Brakes

1. Investigate the cause of loss of brakes under low pneumatic pressure situations.
2. Provide additional procedures for operating the vehicle in situations with marginal or failed braking capability.

Inappropriate Modifications to Dash 10 Document

1. Review essential content of current and past Dash 10 documents and reinstate generic vehicle information.

5.6 CUCV

Following Too Close/Speeding

1. Provide additional unit training for operating the vehicle under adverse operating conditions.

Off Road Travel

1. Provide additional, realistic unit training for vehicle operation under adverse operating conditions.
2. Develop procedures for across slope travel for the top heavy M1028 version of CUCV.

Mounting/Dismounting

1. Provide reinforced, anti-slip coated areas on the surface of the vehicle to facilitate deployment of netting.

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